VOLUME LV AUGUST, 1945 NUMBER 8

THE LARYNGOSCOPE

FOUNDED IN 1896
BY
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PUBLISHED BY
THE LARYNGOSCOPE
640 SOUTH KINGSHIGHWAY ST. LOUIS (10), MO., U. S. A.

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THE

LARYNGOSCOPE.

VOL. LV AUGUST, 1945. No. 8

RHINOLOGY IN CHILDREN, RESUME OF AND COMMENTS ON THE LITERATURE FOR 1944.

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Toronto, Canada.

In this resumé of the literature pertaining to rhinology in children the usual journals have been covered. The articles abstracted have been roughly classified under the headings previously used and follow the usual order.

GENERAL ARTICLES ON ACCESSORY SINUS DISEASE IN CHILDREN.

Hilding[1] contributes an authoritative summary of the known facts concerning the common cold. It is concise, comprehensive, supported with an ample bibliography and deserves study in its entirety.

He defines the common cold as that widespread, mild, afebrile, epidemic rhinitis which occurs principally during autumn and spring months and is characterized by copious, thin, mucinous nasal discharge and a self-limited course of two or three days, which is often followed or complicated by suppurative infections of the nose, sinuses, ears and throat and lower air passages. It is now well established that the etiological factor is a filterable virus. He praises the masterly work of Dochez and his group and summarizes their proof that the etiological factor is a filterable virus. The virus promotes the growth of pathogenic organisms in the throats of patients with colds.

The normal bacterial flora of the nose play a big rôle in colds, not as a primary cause but as secondary invaders.

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, July 30, 1945.

They do not seem to have the power to initiate infection, but it is these organisms which produce suppurative rhinitis, sinusitis, otitis media, bronchitis and pneumonia. They may be carried by a large portion of the population in a community with impunity until an epidemic of colds occurs, and then they invade, giving to the epidemic its characteristic complications. Chilling and wetting associated with sudden temperature changes are definite factors in causation of colds, probably because of prolonged reduced temperature in the nasal mucosa.

The disease is largely spread by droplet infection and could be controlled by isolation like other communicable diseases.

There are three peaks in the incidence each year in most communities. They are September-October, January-February and April-May. The incubation period is 24 to 36 hours and there is evidence that the patient is most infectious during the first day and may be capable of spreading the disease as much as four or five hours before his symptoms begin. The pathological picture is given in detail and must be read. In a limited number of cases the author found that the lytic power of the secretion was reduced at the onset of symptoms and increased again just before improvement began. Cahn-Bronner corroborated these findings and found that the lytic power was not reduced in the secretion of hay fever and hence concluded that the change in colds is not a dilution phenomenon. The author discusses briefly but adequately conflicting observations regarding the pH. There has been a very impressive amount of effort expended upon preventing colds. The results have been disappointing.

Vaccination by bacterial vaccines both by mouth and subcutaneous route appears to be valueless for reducing either the incidence or severity of colds; but vaccination by nasal spray has a scientific basis in the fact that immunity may be local. The immunity following an attack of coryza lasts only three to four weeks. Vitamins have been tried in large groups of patients and have been found to be without value in preventing colds. The sulfonamides have very definite value in the prevention and treatment of the complications of the common cold. That does not mean that they should be used

routinely. McCorda and McConnell demonstrated that air-conditioning does not modify the incidence of coryza. But purification by aerosols, antiseptic chemicals or by ultraviolet light seems to be very promising. Codeine and papaverine seem to have definite value in shortening the course. Steaming often gives symptomatic relief.

Isolation should be practiced whenever feasible. In the author's experience, simple ephedrine in saline solution seems to give about as much relief from nasal obstruction as anything else. As soon as there is any sign or symptom of an approaching cold, his patients are instructed to block the nostril (or nostrils) with clean cotton, tightly enough to reduce materially the inflow of air; the cotton must be changed frequently. By this simple measure, the irritation was greatly reduced and often the swelling did not become great enough to obstruct the air passages.

Crowe,[2] from years of experience in treating children, believes that excessive hyperplasia of lymphoid tissue in the pharynx and nasopharynx (which predisposes to frequent colds, chronic nasal congestion and postnasal discharge) can be greatly improved by two simple and practical methods of treatment; local application of sulfadiazine solution in the nose and nasopharynx to discourage the growth of bacteria, — and beta and gamma irradiation of the pharynx and nasopharynx to remove hyperplastic tissue. The combination of sulfadiazine and irradiation is often better than either of them alone.

The solution he uses for the treatment of an acute upper respiratory infection is 2.5 per cent sulfadiazine in ethanolamines (Pickrell's solution). The patient is instructed to put one-half a medicine dropper full of the solution into each nostril and allow it to flow backward along the floor of the nose into the nasopharynx and pharynx.

This should be repeated 10 to 12 times a day for three days and four to six times a day for an additional week. Most of the drug administered in this way is swallowed and is of little value, since the blood level rarely exceeds 1 mg. per 100 cc. after a full course of this treatment. With each appli-

cation, however, some of the sulfadiazine solution is absorbed by the lymphoid tissue and judging from clinical and bacteriological studies previously reported, the concentration of the drug in the nasopharyngeal lymphoid tissue soon reaches a level that inhibits the growth of pathogenic bacteria.

He has used this method of treatment for prevention of ear and sinus applications in approximately 1,500 patients in the past three years, with results far better than he obtained with any other form of treatment. Until the concentration in nasopharyngeal lymphoid tissue has reached a level that inhibits the growth of bacteria, the treatment is of no value; therefore, it is necessary to begin the local application of this drug as soon as possible after the first symptoms of a cold and use it in large amounts and at frequent intervals for at least a week.

This treatment, continued for a month instead of a week, is often very helpful in chronic nasopharyngitis if the infecting organism is sensitive to sulfonamides. Local irritation of the skin around the external nares may be avoided by applying cold cream. In a few patients with allergic sensitive mucous membranes the sulfadiazine solution causes an increased feeling of rawness, burning and congestion. If this happens, the drug should be discontinued, but in his experience less than 5 per cent have any symptom of allergic rhinitis or any evidence of sensitivity to the drug.

The sulfadiazine treatment gives only temporary relief. The real problem is to get rid of hyperplastic lymphoid tissue, which often extends into the posterior nares, grows up on the anterior wall of the sphenoid, on the lateral walls of the nasopharynx, around and in the orifice of the Eustachian tubes and in other locations that are inaccessible for surgical removal. It so happens that next to the sex cells, lymphocytes are the most sensitive cells in the body to beta and gamma irradiation; therefore, in treating these patients the dosage employed is so small that there is no danger of a burn or a dry nasopharynx in which crusts form. The action of the irradiation is to inhibit mitosis in the germinal centers and thus stop the formation of new lymphocytes. Observation of hyperplastic lymphoid tissue under this treatment

leads us to believe that lymphocytes, like the skin cells, have a brief life cycle, probably not more than two weeks. Under irradiation treatment no new lymphocytes are formed to replace those discarded, and the mass gradually shrinks and finally disappears, leaving the nasopharynx covered with smooth mucous membrane not unlike that on the nasal septum. If the dosage is just right the result is perfect and there is never any recurrence. If the dosage is too great, ecchymoses appear in the nasopharyngeal mucous membrane, but there is no excuse for ever getting a burn.

At the Johns Hopkins Hospital he uses from 800 to 1,000 millicuries of radon with a brass filter 1 mm. in thickness, but a more practical applicator for use in the Army and in civilian hospitals and office practice contains 50 mg. of anhydrous radium sulphate. The applicator is made of monel metal. The handle is 15 cm. in length and the radium-containing chamber 15 mm. in length, 1.5 mm. in diameter and 0.3 mm. in thickness. This allows the passage of more beta rays than the 1 mm. of brass in the radon applicator, but has been used with success in the Hagerstown Clinic for the Prevention of Deafness in Children, which is sponsored by the Maryland State Board of Health and the Children's Bureau in Washington. The results in 259 patients have been as good as those obtained with radon, and the time required for each treatment is only 6.6 minutes. Of the entire group under treatment in Hagerstown, the hearing has improved as much as 40 db. in 39 ears, and 10 db. or more for several frequencies in 127. Fifteen chronically discharging ears are now dry and 15 patients with a history of repeated attacks of acute otitis media have been well since the irradiation treatment was finished. Thirty-two patients treated for severe recurrent upper respiratory infections have had very minor colds during the past winter. Ten patients with infected adenoids had severe asthmatic bronchitis with each cold; five of these have had no attacks during the past winter and the other five are greatly improved, a better result than they ever obtained from operational removal of tonsils and adenoids in children.

Irradiation treatments should never be given until there

has been a thorough inspection with a nasopharyngoscope of the nasal passages, the region of the orifices of the accessory nasal sinuses and particularly the nasopharynx and orifice of the Eustachian tubes. The teeth, pharynx, tonsils and base of the tongue must also be examined. Palpation with the finger or mirror examination of the nasopharynx are not satisfactory, especially in children. It is not the size but the location of lymphoid nodules that is important. Irradiation treatment should be spaced at intervals of four to five weeks, and the nasopharynx must be examined with the nasopharyngoscope before each treatment. Greatly enlarged adenoids are better treated by operative removal, supplemented by irradiation at the conclusion of the operation. Often only one treatment is necessary but the nasopharynx should always be examined again six months later and the irradiation repeated if there are any symptoms or visual evidence of recurrence.

At the Johns Hopkins Hospital approximately 125 patients are treated each month in the out-patient department with beta and gamma irradiation of the nasopharynx. This leaves their beds free for seriously ill patients and at the same time most satisfactory results are obtained in a group of patients who in preirradiation days would have been admitted for operative removal of tonsils and adenoids. For 15 years it has been the practice to irradiate the nasopharynx only, since treatment of the tonsils and pharynx would subject the doctor to too much exposure. If the tonsils are chronically infected, they should be removed, but it is their impression from observation on several thousand patients that the nasopharynx is usually the primary focus from which infection spreads to the sinuses, ears and tonsils. If the nasopharynx is freed of lymphoid tissue, recurrent colds become less frequent and severe, and infections in the sinuses, ears and tonsils often heal spontaneously.

In giving irradiation treatments the best protection for the operator is a distance of 30 feet from the applicator. Two pairs of thin rubber gloves will protect the hands from beta rays while handling the applicator, but the use of a lead-containing apron or gloves as used in X-ray work is of no

value in protection against gamma rays. When not in use, the applicator should be kept in a seven-sixteenths inch hole in the center of a lead cylinder which is from four to six inches in diameter, depending on the amount of radium or radon in the applicator. This hole contains a glass tube filled with alcohol. Before inserting the applicator into the patient's nose, the excess alcohol should be washed off and the applicator dipped into boroglycerine. This prevents nasal secretions from sticking to the applicator and is important because the hands must never be used to wipe the applicator. The first evidence of too much exposure of the hands shows in the nails, which become cracked and ridged. It is also wise to have a complete blood examination at intervals, but with care there is no danger, as evidenced by the fact that many of them have given these treatments several times a week since 1928.

Cecil, Plummer and Smellie[3] present a controlled study of the effect on the common cold of sulfadiazine given orally. The drug was administered orally in a dosage of 1 gm. three times daily for four days. In normal individuals a prompt and marked reduction in the normal nasopharyngeal flow was observed when the blood level of sulfadiazine reached 4 to 6 mg. per 100 cc., but the flora rapidly returned to its former prevalence and distribution two to three days after the drug was discontinued. The clinical course of the treated cases showed no striking difference from that of the controls: however, there appeared to be some amelioration of symptoms due to control of the secondary invaders. The writers discourage the routine use of sulfonamides in the treatment of the common cold except in a few selected cases as a protection against severe secondary infection.

Keith, Ross and Thomson,[4] in a well written article, describe an epidemic of acute nasopharyngitis and scarlet fever which occurred in the new entry section of a R. C. N. base. Alternate ratings were treated with prophylactic doses of sulfadiazine consisting of 1 gm. daily. In the treated group, compared with the controlled group, hospital admissions from these two diseases were notably reduced, as were the sick bay visitors. No significant reactions were observed, 236 were retested for sulfadiazine sensitivity and none

showed positive tests after 10 days to three weeks of sulfadiazine administration.

Although this article records observations on adults, it should be read by those dealing with children because its clinical application to younger patients is obvious.

Schall[5] discusses briefly the histology of the respiratory nasal mucosa and the pathological changes seen in acute rhinitis, chronic turgescent rhinitis, vasomotor rhinitis and atrophic rhinitis and then reviews the treatment of these conditions.

He declares himself definitely against having a patient come to the office for treatment of a headcold on a cold wintry day; the radio-sponsored idea that the stinging of nose drops means that they are penetrating; blockage of the nose as a means of curing a nasal pathological condition; massive suction (which he labels dangerous); and operative procedures to narrow nares that are abnormally wide.

He is an advocate of: nonirritating solutions to open the nose and keep it open; gentle irrigation in the office with Ringer's solution; spot suction; partly closing the windows at night and keeping the bedroom temperature not under 50° F.

McGee, Andes, Plume and Hinton[6] endeavored to assess the value to industry of vaccines in the prevention of the common cold. They experimented with two vaccines given by injection and three given by mouth. The clinical trials were made on groups of industrial and office workers with adequate control groups from the same plants in the October to April period of 1941-1942 and 1942-1943. Five geographic locations were represented by two eastern plants, a midwestern plant, a group of office workers on the eastern seaboard and another in a midwestern city. They concluded that no clearly evident protection against the cold and related acute respiratory infections could be demonstrated in the results of this clinical trial at mass immunization and that the indiscriminate use of cold vaccine now available is not the answer to the problem of industrial absenteeism due to acute respiratory infections.

The *Journal of the American Medical Association*[7] draws attention to a report published in that journal Dec. 2, 1944, and sponsored jointly by the Council on Pharmacy and Chemistry and the Council on Industrial Health of the American Medical Association dealing with the use of so-called vaccines for the prevention of the common cold. The report points out that there is no uniformity in the types of vaccines employed, in their mode of administration or in the method of evaluating the results. None of the vaccines now available has proved value; none can be recommended for industrial groups or for individuals. In spite of the overwhelming evidence on this subject, some pharmaceutic firms continue to engage actively in the promotion and sale of various "vaccines" for the prevention of colds. This constitutes an irresponsible attitude toward the public and the medical profession, no better than most of the claims regarding the alleged benefit to colds from vitamins and proprietary nostrums. The air waves and the drug counters are crowded with so-called preventives or cures of these types, which do not serve any recognizable purpose other than to lighten the public purse.

Simpson, Van Alyea, Hansel, Huenekens, Holinger and Livingston[8] present a lengthy symposium on sinusitis in children. Each of the contributors is an authority on the subject on which he writes. In consequence the contribution should be read in its entirety.

Wishart[9] writes on certain problems common to pediatricians and rhinologists regarding sinusitis in children and outlines the principles and details governing the procedures of diagnosis and treatment used at the Hospital for Sick Children, Toronto.

He clearly states what he means by sinusitis and reviews in detail the histopathology, etiology and various methods of examination for diagnosis including radiographic examination and radiopaques. The use of the nasopharyngoscope is specially stressed. He gives ample consideration to the differential diagnosis of sinusitis from allergy.

He discusses the significance of such symptoms as frequent colds, nasal obstruction, nasal discharge, protracted fever,

cough, postnasal drip, headache, pain, impairment of the sense of smell, conjunctivitis, facial appearance, mental dullness or apathy, edema of the lids and attacks of nausea and vomiting without diarrhea.

Under the heading of treatment are discussed certain measures to improve physiological function; and methods to be used in the child that cannot blow its nose. He states that nose drops, if prescribed should be given for a specific purpose and that the method of administration matters as much as the prescription. As usually given they may not reach the part of the nose involved; in consequence he gives reasons why special attention should be given to the position of the head. He advises that the physician ordering irrigation should take great care to give typewritten instructions in order to avoid dangers when it is done at the wrong time or in the wrong manner.

Because the anterior ethmoid cells, the frontal sinus and the maxillary sinus all drain into a common gutter, the middle meatus, the author has found that treatment directed to the shrinking of this meatus is quite the most effective method of clearing sinus conditions in children. This treatment is carried out in the position and manner described by Sidney N. Parkinson and, for the purposes of his hospital, he has named this treatment the *lateral head-low* treatment. The positions for treatment are shown in a series of photographs posted in all the treatment wards of the hospital. The author has no other form of nasal treatment that compares with this in frequency of use and productiveness of good results. The photographs, prescriptions and instruction sheets are illustrated.

He discusses and illustrates certain little known features of the anatomy of the inferior turbinate and of the ostia of the sinuses to demonstrate that both the inferior turbinates and the ostia of the sinuses cannot be traumatized without doing serious damage to the physiological reactions of the nose and sinuses.

As a consequence he claims that certain surgical procedures recommended in textbooks of rhinology should be con-

demned; *e.g.*, reduction, coagulation, cauterization and crushing of an inferior turbinate. The anatomical considerations described should indicate that the inferior turbinate is a structure of great physiological importance. No matter what its appearance or size, disturbance of an inferior turbinate in a child is practically never primary — it is always secondary to disease or abnormality elsewhere in the nose.

In the surgical treatment of the more severe forms of sinusitis, aspiration and irrigation of the maxillary sinuses by puncture of the nasoantral wall has been found the most useful procedure. He gives reasons for condemning procedures such as washing of the antrum via the natural ostium, treatment of sinusitis by displacement, the use of tampons or packs, and short wave therapy.

As regards type of operation, each case must be individualized. The surgeon's task is to know accurately the patient's condition, devise a procedure which can logically be expected to improve that condition, and then have the skill to do exactly the amount planned. He must endeavor to do enough to insure his patient as good physiological activity as possible with a minimum of impairment of function. His duties do not stop there — for he must continue *personally* to do the after-treatment.

He concludes by emphasizing the importance of early recognition and treatment of sinus disease to prevent it becoming chronic. Ten figures.

Johnston[10] presents a short article on the diagnosis and treatment of nasal sinus disease in children. Nearly all of the article consists of short references to his bibliography. The subject is developed in a consecutive way by quotations which he rarely comments upon. Now and then he makes a pertinent observation. This makes a review most difficult and the reader is asked to consult the original article.

He makes the valuable remark that regardless of the prevalence of nasal sinus disease, it is constantly being overlooked by many physicians who are not aware of the anatomical peculiarities of children. His bibliography does not include Onodi's Accessory Sinuses in Children, which, though pub-

lished in 1911, is still the most complete source of such information.

Bell[11] states that chronic nasal discharge in small infants with resulting snuffles or nasal obstruction is a very common symptom. The origin of these snuffles is probably a mild catarrhal infection of the nose, but the persistence of the symptom is often due to mistaken attempts to clear the nose with pledgets of cotton-wool. These pledgets are useless for the purpose for which they are intended, and the delicate mucous membrane of the infant's nose is always irritated and often injured by their use, and a chronic infection results. Most cases of snuffles will clear up when the use of such pledgets is discontinued.

Whether tonsils should be removed or not is a question asked frequently in welfare center practice. It clearly requires careful and individual consideration. No one who has seen some of the bad results of indiscriminate tonsillectomy will fail to realize the importance of a right decision. The tonsil undoubtedly plays a large part in the defense of the respiratory tract of the young child against infection, and its removal while still capable of healthy function will only weaken the defense. He does not think it is an over-simplification of the problem to state that there are but two indications for the removal of the tonsils in children under five years old. The first is hypertrophy of the tonsil to a degree which interferes with the child's swallowing; the second is chronic infection of the tonsil, resulting either in repeated autoinfection of the respiratory tract or in the child becoming a carrier of pathogenic organisms which cannot be eliminated by other means. It is important to remember that a history of repeated acute infections in the child is not necessarily an indication for removal of the tonsils. The repeated infections may be due simply to repeated exposure to an outside source of infection. The same principles should be applied to consideration of the removal of adenoids. The adenoids should be removed if they are the site of chronic infection or if their hypertrophy obstructs the nasal airway or interferes with the drainage of the paranasal sinuses or middle ear.

TREATMENT OF ACCESSORY SINUS DISEASE.

McMahon[12] is of the opinion that in the treatment of sinusitis in children the constitutional imbalance should be properly adjusted by an adequate diet, removal of offending allergens, and supplementary vitamin therapy. The environmental predisposing factors should be corrected as well as it is within the jurisdiction of the otolaryngologist to do so. Therapeutic aids should be used as indicated; *viz.*, calcium, iron and thyroid medication. Every effort should be made to treat the local infection as intensely as conditions permit by the use of suction, nonirritating intranasal medication and displacement irrigations. Nasal irrigations carefully administered with physiologic sodium chloride solution are beneficial in liquefying and removing the purulent secretions and preparing the nose for carefully instilled intranasal medication. Certain serious constitutional diseases have their origin in latent as well as manifest sinusitis, which may, at times, be unsuspected. The ultimate success of the treatment of sinusitis in children depends upon the cooperation between the otolaryngologist and the pediatrician.

Russell[13] states that sinus trouble is common in children, in whom the exanthemata pave the way for streptococcal infection. It would probably be recognized more often if it were realized that effective palliative treatment is possible.

The typical tissue-response to streptococci is production of edema, not pus. Insistence upon pus for diagnosis of sinusitis has occasioned nonrecognition of numerous cases, in which Vth nerve irritation and local absorption along the lymphatics produce symptoms customarily regarded as primary (*e.g.*, "neuralgia") in parts remote from the sinuses.

Dyes absorbed from the sinuses may appear in the urine in 20 minutes, and be recognized also in the brain and in the cervical and upper dorsal musculature.

Tonsillar inflammation is usually a result of sinusitis, as are also otitis media, conjunctivitis, headache and many types of deviation from normal behavior.

It is wise to assume that the sinuses are involved in most of the exanthemata, influenza and pneumonia, and to initiate

palliative treatment without delay, if chronic inflammation is to be avoided. The most cogent result of acute inflammation of the linings of the sinuses and of the nasal passages is the mechanical difficulty occasioned at the ostia by swellings of the membrane in an inexpansible bony ring, which leads to "sinus-block." The indication, therefore, is to reduce the edema at the ostia so as to permit the normal entry of air into the sinuses and to facilitate the escape of the increased secretion.

This can be achieved by the introduction of nontoxic volatile vasoconstrictors, such as methedrine or benzedrine, or fluids from a fine spray: Neosynephrin hydrochloride in 0.25 per cent solution is the best so far obtainable. Ephedrine hydrochloride, 0.5 per cent in normal saline, is also effective. If the nasal lining is sensitive it is desirable to spray with

Cocaine hydrochloride	4%
Ephedrine	1%
Potassium sulphate	0.5%

(The displacement method is illustrated by four diagrams and photographs of the X-ray findings when the iodized oil is accepted normally by the antra and the sphenoids.)

The principle of the displacement method is the partial withdrawal of air from the sinuses with a modified breast pump, the head being inverted and the nose filled with 0.5 per cent ephedrine hydrochloride in normal saline, the solution replacing the air in the sinuses upon discontinuance of the suction.

Displacement has been found effective, particularly in young children, and is practiced at the Metropolitan, Ear, Nose and Throat Hospital, Paddington Green Children's Hospital, St. Bartholomew's Hospital in this country, and extensively in America. Operation is rarely indicated; antral empyemata can frequently be emptied by displacement treatment, which may be repeated with advantage after an interval of five minutes.

Lipiodol, similarly introduced, is valuable in radiological diagnosis. Mucosal swellings, often vaguely indicated in

plain X-rays, are clearly shown against the contrast medium. Rapid alterations in mucosal thickness, suggesting urticaria, are demonstrable in asthma, migraine and epilepsy.

Birdsall[14] for the past eight years made a systematic study of the problem of sinusitis in children, his cases being chiefly drawn from the large out-patient clinic at Paddington Green Children's Hospital. He recorded in 1939 the clinical features of 80 cases of indisputable sinusitis, and as these were selected particularly because the diagnosis was proven beyond all dispute, it may be confidently assumed that the facts which they illustrate are to be regarded as reliable evidence.

It is very rarely that the sinusitis of children is not readily discernible by the ordinary methods of examination, if properly performed.

During eight years he has never allowed himself to fail to examine any children by anterior rhinoscopy. A small speculum is essential, but in children under three the anterior nares are greatly widened simply by light pressure on the tip of the nose. The absence of vibrissae and the short vestibule render anterior rhinoscopy easy in the child.

In his series of 80 cases the etiological factors were difficult to assess, and in only 13 was there good enough evidence of an antecedent cause. Of specific diseases, whooping cough is undoubtedly the commonest, unless we regard the common cold as a specific infection. All the specific fevers except mumps and chicken pox are common precursors of sinusitis. Sinusitis is probably as common as otitis media as a complication of scarlet fever, and culturally identical streptococci have been recovered from the ear and from the antrum of the same side in postscarlatinal otitis media.

The symptom of sinusitis in children, if considered in a logical way, point to the sinuses as the probable source, though such symptoms are often ascribed to infection to the tonsils and adenoids.

He finds that the commonest symptoms leading to a request or even a command for tonsillectomy and removal of adenoids are: frequent so-called colds, snoring, mouth-

breathing (never confirmed by observation), backwardness, both physical and mental — none of which can logically be attributed to disease of the tonsils or adenoids, or a host of miscellaneous disorders such as bed-wetting, nose-picking, habit-spasms — including various nonpathological coughs, and even juvenile delinquency!

Mouth-breathing is of enormous importance, not because the condition is common, but because it is rare. When it occurs it is a sign of either sinusitis — almost always, or of two very rare conditions — congenital atresia of the posterior choanae or a nasopharyngeal tumor. A very instructive experience can be enjoyed easily by visiting a children's ward at night. The proportion of children who are sleeping with open mouths will be found to correspond very closely with the proportion whose age is below six years, the age at which the mandible begins to grow rapidly to accommodate the permanent teeth. The "mouth-openness" of the small children, misnamed mouth-breathing, is cured by increasing length of the body of the mandible. Moreover, the angle of the mandible, 175° at birth, is reduced to 110° after puberty. Whether the patient is breathing through the nose or through the mouth can be easily determined if the observer will quietly approach with a cold spatula, and hold it beneath the nostrils.

In his own series of 80 cases the symptoms in order of frequency were:

a. Nasal obstruction. One-half of the children with this prominent symptom had previously undergone tonsillectomy and removal of adenoids. In only one case was the obstruction due to adenoids. It was usually caused by a combination of mucosal edema and the presence in the meati of the nose of thick mucopus.

b. Cough will occur as a direct consequence of downwardly propelled sinus secretion.

c. Colds. If a child is said to be "never free from a cold," it may be presumed that he has sinusitis. He believes allergic nasal conditions to be very rare in children. The allergic nasal mucosa of adults is in its appearance characteristic, extreme pallor, swelling and irritability. He has very few

notes of its occurrence in children, and does not recollect having recorded it except in hay fever.

d. Anorexia. This symptom was in definite relation to the magnitude of the suppurative reaction.

e. Otorrhea. It is his opinion that the vast majority of children with chronic otitis media have sinusitis, and the significance of this conclusion merits a special discussion.

In the adult the classical description of pus in the middle meatus of the nose is very often not demonstrable on the rhinoscopy. In the child it is usually obvious. Indeed, the mucopurulent secretion commonly fills the inferior as well as the middle meatus, and the presence in the normal path of inspired air explains the outstanding symptom of nasal obstruction. The diagnosis, therefore, is simple. The only other conditions which will thus fill the lower half of the nose with mucopus are nasal diphtheria, foreign bodies and congenital syphilis. If such a condition be found on two occasions separated by a fortnight's interval, it is not due to the common cold.

Cure depends only on recognition of the disease. Ephedrine in saline nasal drops is in a very great many cases successful. If anterior rhinoscopy shows signs of active disease after a week, ephedrine replacements are given. The age of the child is now no longer regarded as a factor in this decision. His nursing staff will, if asked, give a replacement to any child of any age, usually with, but if necessary without, his cooperation. If still uncured after one month, puncture lavage of the antra rarely fails. In less than 10 per cent of his very severe cases, operation was necessary. When operation is necessary the Caldwell-Luc approach is preferable in children.

In the discussion that followed the presentation of the preceding two papers, Mr. T. B. Layton criticized the speakers for having lumped together a number of different pathological conditions under the term "sinusitis."

Culpin[15] writes that in his experience as an honorary ear, nose and throat specialist to a hospital for sick children in

Australia, the subject of "sinus disease" is an increasing enigma. He believes that sinus disease is a local manifestation of a general biochemical abnormality. For years he has developed the idea that this sinus disease was connected with a deficiency of vitamin A. He outlines his methods of treatment.

TREATMENT OF OSTEOMYELITIS OF THE FRONTAL BONE.

Williams and Nichols[16] state that two cases of spreading osteomyelitis of the frontal bone in which a favorable result was obtained apparently by the administration of penicillin hold great interest for the rhinologist because osteomyelitis, although fortunately infrequent, is one of the complications of sinus disease and of sinus surgery in which therapeutic efforts, both medical and surgical, have been relatively disappointing. One of the cases reported was that of a child and was remarkable in that it was the second of two cases seen at the Mayo Clinic in which a pure culture, hemolytic staphylococcus aureus, was found.

Two weeks before admission the patient, aged nine years, complained of pain in his left eye. The patient's temperature rapidly rose to 104° F. Blood culture revealed staphylococcus aureus. Seemingly adequate doses of sulfadiazine were begun but the next day he was irrational and had a temperature of 105° F. On the third day he had convulsions with loss of sphincter control. On the fourth day of the disease a swelling appeared in the midfrontal region, and in an hour's time the left eyelid was swollen shut. The blood continued to show the presence of staphylococcus aureus, and after running a stormy course for two weeks the boy was referred to the Mayo Clinic.

On arrival the patient's temperature was 102° F., and there was a fluctuating tender swelling in the midfrontal region. Examination otherwise revealed nothing of significance. The Roentgenogram revealed pansinusitis on the right side and blood culture revealed the presence of 100 colonies per ccm. of hemolytic staphylococus aureus in 12 hours. Pus aspirated from the subperiosteal abscess in the frontal region revealed the same organism.

The patient was given penicillin by the continuous intravenous drip method for 14 days. He received 44,000 Oxford units of penicillin in two liters of physiologic saline solution during the first 24 hours and 33,000 Oxford units of penicillin in a similar solution daily thereafter.

Blood culture became negative within 72 hours after treatment with penicillin was begun. The frontal swelling failed to recede, however, and on the sixth day of treatment this swelling was incised transversely. An abscess filled with pus and infected granulation tissue was exposed. This abscess continued to refill from below, and a fistula in the frontal bone was found. This fistula was enlarged and a huge epidural abscess was encountered over the frontal lobe. This abscess contained about 4 oz. (120 cc.) of pus which pushed the dura of the frontal lobe back at least

5 cm. from the inner table of the frontal bone. The diploe of the bone at the periphery of the opening was oozing yellow pus. The wound was packed open.

Administration of penicillin was continued for seven days after drainage of the abscess. The patient improved rapidly and was dismissed from the hospital on the fifth day after the operation. The wound was allowed to granulate in. The patient was observed for two weeks more and then allowed to go home. He returned in a month for observation and no evidence of disease could be found.

Osteomyelitis as a complication of frontal sinusitis has been and still is greatly dreaded. Reference to critical reviews of rhinology in children of other years will show that drastic surgical removal of bone has been required in many cases to effect recovery. Your author has recently been active in the treatment of such a complication and has seen what up to now has been a miraculous recovery without removal of any bone and due almost entirely to the proper use of penicillin. This case will be reported in due time.

Osteomyelitis in the practice of rhinology is fortunately rare — but it occurs more often in the practice of general surgery. Hence the principles and methods used by the general surgeon to combat this disease always should be studied by the rhinologist.

It is proper, therefore, to direct the attention of rhinologists to articles on the treatment of osteomyelitis with penicillin appearing in surgical journals because penicillin is the most effective therapeutic agent yet discovered for the treatment of staphylococcic infection, as in chronic osteomyelitis.

Anderson, Howard and Rammelkamp[17] present a critical study of this disease in 40 patients to evaluate the effectiveness of penicillin for this disease and to determine if possible the most satisfactory method of employing this new therapeutic agent. They have been cautious in their conclusions and state prolonged observation of every patient after the completion of treatment is necessary before final conclusion can be established. Penicillin is remarkable in its lack of significant toxicity. They state that penicillin by inhibiting the growth and multiplication of bacteria will arrest the infection in a high percentage of cases of chronic osteomyelitis and thus allow healing of both bone and soft tissue to take place.

They state that primary closure following sequestrectomy or evacuation of an abscess of a bone is a safe and satisfactory procedure for patients who are receiving penicillin.

Goodhill[18] reports the case of a five-year-old boy with acute fulminating bilateral cavernous sinus thrombophlebitis and with a positive blood culture yielding hemolytic staphylococcus aureus. This followed furunculosis of the central part of the forehead. The patient was treated with sulfathiazole and heparin for a week, during which time the disease progressed rapidly. With penicillin treatment there was an apparent dramatic response and within seven days the child became afebrile, although the blood culture still remained positive. At the end of the second week with penicillin the patient was able to leave the hospital. Three illustrations.

TREATMENT OF EPISTAXIS.

Fox[19] reports that he has treated more than 100 patients, both children and adults, for recurrent or acute epistaxis due to septal varicosities by injections of a sclerosing agent (sylnasol) intramucosally at the site of the bleeding point or varicosities. The results have been uniformly satisfactory; active bleeding has been controlled immediately, and the vessels subsequently have become obliterated by sclerosis so that recurrence of the bleeding is obviated. From 0.25 cc. to 0.5 cc. of sylnasol are employed, and this is injected intramucosally (not submucosally). Injection into the vessels themselves has not been attempted nor is it advised, since the intramucosal injection is safer, has the immediate effect of controlling active hemorrhage and is equally efficient in the subsequent sclerosing process. In addition, all the vessels of a given area are affected by the injection when it is done intramucosally, whereas only one vessel would be affected if the vessel itself could be injected. Usually one injection is adequate at each site for the control of bleeding or the obliteration of varicosities. No complications and no serious side effects have been observed.

ALLERGY.

Miller[20] states that, in 1941, from a series of 100 cases taken at random in which polypectomies were done at the

Massachusetts Eye and Ear Infirmary, polyps were sectioned and studied histologically. In every single polyp there was a marked eosinophilia just below the epithelium; this was less marked throughout the remainder of the polyp.

The finding of eosinophilia either locally, as in nasal smears, or in the blood stream or in polyps in the presence of one or many of certain symptoms, has usually been considered as an indication of allergy, although the absence of eosinophiles in nasal secretions does not rule out the presence of allergy.

The findings made in this series of polyps stimulated the author to study eosinophilia. He discusses the normal locations of eosinophiles and some of their variations in the body and then enumerates such a long list of pathological conditions in which eosinophilia is found as to suggest that there is no possible single function of the eosinophile. He believes, however, that there must be some rationale to such a cell, and from studies of the eosinophiles in relation to histamine he presents the idea that the eosinophile may act as a histamine carrier.

ANATOMY AND ANATOMICAL ABNORMALITIES.

Hilding,[21] in his latest contribution to the study of the physiology of the drainage of nasal mucus, states he had hoped in his fourth article to give a complete study establishing the manner of the drainage of mucin from all of the nasal sinuses in man, but that the difficulties of obtaining sufficient suitable material had been greater than expected and in consequence his study is, in his opinion, by no means complete. Observations were made on the maxillary sinuses in living patients and on the other sinuses at autopsy while the bodies were sufficiently warm so that the ciliary action was still largely unimpaired.

In general, each sinus exhibited a spiral manner of drainage similar to that in the frontal sinus of the dog. The spiral was directed anteriorly and inferiorly across the lateral wall, then medially across the anterior wall and floor to the ostium. No very satisfactory observations were made in the ethmoids. In the sphenoids, the spiral was found very similar to the

one found regularly in the frontal sinus of the dog; that is, from the deeper portions of the cavity, laterally up and anteriorly across the lateral wall, then medially across the anterior wall to the ostium.

In the maxillary sinuses the India ink spiraled similarly to the ostium; some crossed the roof just before reaching the ostium. In no specimen was the ink observed to pass out through the artificial window. Obviously, if a large mass of secretions were present, it would flow out through the window by gravity into the inferior meatus and, by ciliary action, be carried postoperatively into the pharynx.

This brings up the question of the rationale of sinus irrigation. Keeping in mind the physiology of ciliary drainage, what do we accomplish by irrigation of the maxillary sinus during an attack of sinusitis? That depends upon the nature of the pathological conditions present. If the sinus is filled with creamy pus and the mucous membrane entirely destroyed, then the condition is essentially an abscess cavity in a bony tissue and removal of the pus has the same beneficial effects that it has in other abscesses. Usually, however, the lining mucous membrane is not entirely destroyed and the condition is somewhat different from that in the case of an abscess cavity. The exudation is not in direct contact with the connective tissues but is separated from them by a surface of mucous membrane as far as this remains intact. By means of its ciliary activity, this membrane drains the sinus of the normal thin film of mucin about every 15 minutes. Gravity does not materially retard the drainage of the normal film as it passes up the more or less vertical walls to the ostium, because it is thin enough and viscid enough to adhere closely to the tips of the moving cilia.

When the amount of the secretion is sufficiently increased, however, the film becomes so deep that when the vertical walls are reached only the deepest portion of the film next to the tips of the cilia go on through the ostium, while the superficial portions of it slide back to the bottom of the cavity by gravity. In this manner the secretion may accumulate until the cavity is full. The volume need not become very great before the cilia are many hours behind in their activity

of keeping the cavity empty. If the accumulation of secretion can be removed by irrigation, the deleterious effects, whatever they may be, are avoided, and the cilia are relieved of a great many hours of labor and given a fresh start. If they are not given this help, the destruction may become sufficiently great to allow the infection to become chronically established.

All of the sinuses of man seem to drain the normal film of mucin with a spiral motion centering at the ostium. The direction of the flow of mucin is not altered by making a window into the inferior meatus. It is still directed toward the ostium as it was before. When an abnormally large quantity of secretion is contained, this also is directed toward the ostium, although much of it doubtless flows out of the window by means of gravity.

The lymphatics have often been suggested as the probable pathway along which infection extends from the paranasal sinuses to the lungs, a recent writer even stating that "lymphatic drainage from an infected sinus causes the tracheal cough so characteristic of sinus infection." A possible relation between chronic sinusitis and bronchiectasis is not to be doubted, but the question of the mechanism by which infection spreads from the sinus to the lung has not been answered.

This was the opinion of Dixon and Hoerr,[22] who were stimulated by it to investigate the current views on the subject with the result that they have formed opinions at variance with conclusions of Mullin, Larsen and Fenton.

From experiments on rabbits they conclude that the lymphatic drainage of the maxillary sinus is a fairly slow process and is confined to the lymphatics of the lateral nasal and nasopharyngeal walls, vessels which empty into the retropharyngeal and jugular nodes — and, further, that all colloidal material is trapped in the nodes and does not reach the blood stream.

The clinical lesson they draw from their experiments : that the lymphatics play no part in the relationship between infections in the sinuses and the lungs. They feel that

dependent drainage from the upper respiratory tract with its mechanical obstruction and irritation is the deciding factor. The persistent explosive coughing effort to remove this accumulation so injures the bronchi that they do not return to normal.

Jervey[23] reports a case of congenital occlusion of both anterior nares.

D. B., age six months, had never breathed through her nose, yet never had any great difficulty in nursing. About one-quarter inch in from each anterior naris there was a complete occlusion of the nasal passage. The nose otherwise appeared well formed and there was no other demonstrable abnormality.

Five years later, the occlusion in the right naris had apparently become absorbed so that a definite web structure was observed, in the middle of which was a tiny round opening about 2 mm. in diameter. The occlusion of the left side was still complete.

The opening in the right naris was rapidly dilated to admit a No. 16 lacrimal probe and a suitable piece of tight-fitting rubber tubing was pushed through the left in situ with a safety pin across the protruding end. This was taken out daily by the mother and cleaned and reinserted after mild anesthesia with pontocaine. The tubing was cut to about 1½ inches in length and the tip was cut on a long bevel so that the piece could be inserted easily and with increasing pressure as it was pushed in to the limit. As the opening in the web became larger, a tube of larger size was substituted so that in a month's time the vestibule opening was approaching normal size.

At this period, under light general anesthesia, the web in the left naris was split vertically with a submucous knife which went readily through into the nasal passage. There was very little bleeding. The web was about one-eighth of an inch thick. The interior of the nose appeared normal. Each naris was packed with a finger cot filled with vaseline gauze packing. This was left in situ for six days.

There was no trouble at removal, nor has there been at any other time. The packs were replaced by a rubber tube in each nostril with one safety pin through both protruding ends. The device through which she breathes easily is worn at night and dispensed with during the day. She was last seen five weeks after operation when both passages were virtually normal in size and appearance.

Graves and Edwards[24] present a thoroughly considered study of the structure and function of the Eustachian tubes. The work was done in the Departments of Anatomy and Medicine of Ohio State University. The greater part of the paper is concerned with the Eustachian tube of the adult, but there is a long section dealing with the Eustachian tube of the newborn and this section has nine excellent original illustrations.

It has been stated that the tympanic cavity of the newborn is filled with myxomatous tissue and detritus. The authors, however, agree with Wolff that there is no indication of detritus or myxomatous tissue in the tympanic cavity or the tube of the infant. They agree with Braislin that the most conspicuous landmark in the lateral wall of the nasopharynx is the prominence of the cartilaginous extremity of the Eustachian tube, which stands out sharply from the side wall. The elevation or torus made by the tubal cartilage lies as a curved hood over the superior and posterior margins of the orifice. But in contradistinction to the adult, a true anterior pole does not exist in the infant; however, the levator torus is much accentuated and sweeps directly medially in a horizontal plane. All this is in marked contrast to the adult condition in which growth has stretched the folds into more vertical positions.

In dimensions, the infant's tube is one-half the length of that of the adult, averaging 18 mm., although Kerrison gave the length as 14 mm. and Bryant as 20 mm. The pharyngeal portion of the tube maintains in length two to one ratio to the osseous portion, as in the adult. The lumen of the pharyngeal portion is about the same width (1 mm.) as that of the adult, although the height is nearly one-half that of the adult for comparable sections. The direction of the tube in the newborn varies from a horizontal plane to one of about 10° of inclination.

The tensor palati muscle is well formed at birth and has an extensive attachment to the well defined lateral fibrous membrane (salpingopharyngeal fascia) and to the hook of the tubal cartilage. It is the function of this muscle to pull on the salpingopharyngeal fascia, which supports the underlying mucosa, therefore opening the closed or resting tubal lumen. Since the tensor palati muscle is brought into contraction during swallowing, it is the custom on commercial airliners to induce regular and frequent swallowing by having the baby suck the nippled water bottle. This act, or that of swallowing, causes the newborn infant to increase the normale (awake) rate of swallowing of five times a minute to 20 times a minute. Equally important, as with adults, the

sleeping infant must be awakened in descent of sleeper planes, for the swallowing rate is only once in every three minutes when the infant is asleep.

In order to correlate anatomic and physiologic facts with certain clinical observations and applications, detailed microscopic appearances of various portions of the infant tube are described.

The pharyngeal orifice of the tube deserves major emphasis as it is the site of the greatest assault by mechanical factors, infection and therapeutic maneuver. Here the thick pseudostratified epithelium of the pharyngeal wall continues over the elevated margin of the orifice of the tube, dips into the funnel and then gradually thins as it nears the tube proper. Tiny pits over the surface of the torus admit to the openings of the large number of small compound tuboalveolar mucoserous glands which lie embedded in the loose tunica propria.

The vascularity of the orifice of the tube is well illustrated and the subepithelial and glandular network are distinctly seen. Clearly does this bring out the enormous potentialities of irritants to bring about engorgement in such an extensive vascular bed and, indeed, to cause edema in the loose fibrous tunica propria supporting this vascular network.

In the cartilaginous portion the authors find cilia on both the pseudostratified epithelium and also the epithelium of a simple columnar type. This is an important observation because Wolff had claimed to have found cilia only on the roof near the pharyngeal end.

The mucoserous glands numerous at the torus occur in the medial and lateral walls of the cartilaginous portion but gradually disappear entirely about half-way up the cartilaginous portion of the tube.

They describe a subepithelial collection of lymphoid tissue, known as the tubal tonsil, about 3 mm. lateral to the pharyngeal orifice on the medial wall. This tonsil is located well superior in the tube. Countless lymphoid nodules are found in the middle part of the cartilaginous tube in the child. Such

tubal tonsils cause a raised hillock of mucosa, giving a clue to their importance in tubal occlusion by enlargement.

The epithelium of the infant is everywhere pseudostratified. Cilia are found throughout.

In the osseous portion the pseudostratified epithelium of the mucosa is covered with cilia and at the tympanic ostium the mucosa is similar to that found elsewhere in the tube — that is, pseudostratified and ciliated.

FOREIGN BODIES.

Thornell and Williams[25] present a case of foreign body involving the floor of the orbit and the antrum because it illustrates the principle that persistence of a draining fistula following apparent removal of a foreign body is highly indicative that a portion of the foreign material is still present in the region. The presence of some form of infectious granuloma, or a sequestrum, or osteitis, or osteomyelitis, may also be suspected. This case also demonstrates the ineffectiveness of a Roentgenogram in the diagnosis of foreign bodies which are not radiopaque. Two photographs.

A girl, three years of age, had fallen on a small branch which had penetrated through the floor of the orbit into the left antrum. A portion of the foreign body had been removed but drainage had continued from a fistulous tract at the point of entrance of the foreign body.

The fistulous tract led into the anterior ethmoid region and the antrum from above. A moderate amount of mucopurulent discharge was present in the left middle meatus. The Roentgenograms revealed clouding of the sinuses on the left with opacity of the left antrum, but there was no evidence of a foreign body.

Incision was made parallel to the lower margin of the orbit. The periorbita was separated from the bone, and extensive sequestration of the roof of the antrum was found, together with a foreign body, 5 cm. long and 1 cm. in diameter, which lay in the floor of the orbit and the roof of the antrum diagonally from above backward and downward, penetrating the ethmoid cells posteriorly. Diseased granulation tissue was removed from the antrum and the ethmoid cells, and a large antral window was made to insure adequate drainage. Crystals of sulfanilamide were placed in the antrum and the ethmoid region. The postoperative course was uneventful.

PHARMACOLOGY.

Lierle and Evers[26] present the results of experimental work to show the effects of certain drugs commonly used in office

practice upon the cilia of the mucous membrane of the upper respiratory tract. Extirpated human nasal mucosa was used.

Twenty tables show the results obtained with the following solutions: 0.5 per cent solution of chlorbutanol in normal saline; saturated solution of sulfanilamide (0.9 per cent); 5 per cent isotonic solution of sodium sulathiazole (freshly prepared); 5 per cent solution of sodium sulfathiazole without sodium chloride to make it isotonic; 2.5 per cent sulfadiazine in triethanolamine and butoben; triethanolamine and butoben (solvent only), sulfanilamide powder, sulfathiazole powder, sulfadiazine powder, and penicillin, 5,000 units per cm. of normal saline; 2-aminoheptane sulphate (Tuamine sulphate) and 2-amino-4-menthyl hexane sulphate (Fouramine sulphate).

The evidence and the conclusions should be studied in the original.

Griesman[27] has made Roentgenographic studies to determine the mechanism of transmission of oily substances sprayed into the nose to the lower respiratory tract in a series of 31 patients with no history or evidence of infection of the upper respiratory tract. Of these, five were children. He makes the following conclusions:

1. Healthy persons, irrespective of age, might aspirate oil (primarily when sprayed) even in therapeutic dosage if the oil is improperly administered.

2. The presence or the absence of tonsils and adenoids and the use of a 1 per cent solution of an ephedrine salt prior to the administration of oil apparently do not increase the danger of oil aspiration.

3. Scarring in the tonsillar beds and injury to the posterior pillars after tonsillectomy tend to increase the danger that oil will be aspirated if the oil is incorrectly administered.

4. Oil is carried downward by the force of gravity.

5. The decisive factor of safety or danger is the position in which the head is held during and after the administration

of oil. The danger begins and increases with the size of the angle of the backward inclination of the head. There is no danger when the head is held straight or bent forward, even when massive doses many times the normal therapeutic dose are employed. The factor of safety increases with the size of the angle of the forward inclination of the head.

Butler and Ivy[28] have investigated the question of the method of administration of drugs to the nasal mucosa. Their article is well illustrated. They come to the following conclusions:

Comparative studies of the efficacy of methods of application of vasoconstrictor drugs to the nasal mucosa indicate that volatile inhalers and nasal sprays are similar in intensity and duration of effects produced, while nasal drops are far less effective as a method of medication.

The effects on the nasal mucosa produced by repeated administration of inhalers and sprays are similar, and both produced far less pathologic change than that resulting from the use of nasal drops.

It would seem that the selection of methods of medication in acute rhinologic conditions should be limited to nasal inhalers and sprays in most instances. When medication is desired in local areas of the nasal chamber, as at the ostium of a paranasal sinus, drops may be the method of choice.

In conditions requiring prolonged and repeated medication, nasal drops should be used with caution, and sprays or inhalers are suggested as the methods of choice.

Gollom[29] contributes an article on the problem of nasal medication as a means of alleviating nasal symptoms. He states and deplores the fact that the public has become educated to the use of nose drops, stating that during one week ending Feb. 24, 1942, the American Institute of Public Opinion estimated that a total of 23,000,000 persons suffering from the common cold spent approximately $11,500,000 on medication. He reviews briefly the physiology of the nose, pointing out that the lining membrane of the nose is continuously in the process of adaptation to changes resulting

from acute infection, weather conditions, smoke, dust and chemical substances. Just beneath its epithelium lies the tunica propria, a loose fibroelastic connective tissue network. It contains cells of all kinds, particularly lymphocytes, numerous glands and a rich supply of blood vessels. The arteries form a capillary network just beneath the epithelium and around the glands. It is this arterial network which is acted upon whenever a vasoconstrictor drug is applied to the mucous membrane.

In acute and chronic inflammation of the nasal mucosa, there occurs a proliferation of powerful inflammatory cells in the tunica propria, mainly polymorphonuclear leucocytes, lymphocytes, histiocytes and fibroblasts. Most of these cells have phagocytic properties of great importance in engulfing pathogenic organisms.

The pH of the nasal secretions has been found to affect the bacterial flora of the nose. He points out that there is still disagreement regarding the optimum pH. He mentions certain of these disagreements and shows why strengths of certain solutions adversely affect ciliary action.

In the search for the best vasoconstrictor, Fabricant and Van Alyea, in 1942, recommend a new and effective nontoxic nasal vasoconstrictor called privine HCl 0.1 per cent. This is isotonic and has a pH of 6.2. The same authors in January, 1942, again described this drug and found it to fulfill the criteria necessary for good nasal therapy. In addition, its decongestive action appeared to last longer.

Gollom states that in 1943 it was his experience to see more than 30 patients who became more or less addicted to the use of privine for the relief of nasal obstruction and it became his impression that the obstruction was prolonged by the use of privine and that relief was obtained only by discontinuing this drug.

He states that after seeing a few such cases it became fairly easy to make the diagnosis by means of a careful history before a rhinological examination is done. Here is a typical story.

A patient develops a head cold. After a few days, with the nose a little stuffed, the patient seeks relief from doctor or pharmacist. Privine gives quick relief as it is apparently a rapidly acting vasoconstrictor. At first, two or three applications in 24 hours are sufficient; however, the ultimate relief of permanent decongestion becomes more elusive and the patient begins to use the drug oftener. He has seen patients who felt compelled to use privine HCl every two or three hours, day and night. If the patient attempts to discontinue the drug, he complains of a feeling of suffocation. The nose blocks up tightly and the throat feels constricted. It is a common story for the patient to start with a half-ounce bottle and, weeks later, when his nasal condition should have been a thing of the past, he is found to have graduated to 4 oz. bottles as the net cost per cc. is less.

The appearance of the nasal mucosa is typical. When the privine effect wears off, the turbinates are found to be swollen, possess a somewhat dough-like feel and appear a little paler than usual. The patient may have some discharge but complains mainly of blockage. He feels grateful to privine for whatever momentary relief he gets.

The treatment is simply to discontinue the use of privine. This is very difficult to plan, as the patient is fearful of the nasal obstruction that ensues, especially at night. Nembutal, gr. 1.5 or gr. 3, for the first couple of nights is helpful. By the third day the chronic congestion has begun to subside. It takes at least 10 days for complete relief.

The author illustrates his contention by four case histories.

He concludes — privine HCl 0.1 per cent can be a potentially harmful drug when used without supervision or for prolonged periods. A few days is the longest it should be used at any one time. As an aid in avoiding its harmful effect, its sale should be limited to prescription only.

TONSILS AND ADENOIDS.

The writer of this resumé of the literature has endeavored to present the views of the author of each article reviewed without bias, even when the views presented, in his opinion, are not entirely warranted. One such presentation in the

resumé of 1943 has been subjected to well considered criticism as follows:

Illingworth,[30] though in favor of leaving tonsils in unless there are very definite local indications for their removal, took exception to statements in an annotation entitled, Health and Tonsillectomy, in the *British Medical Journal*, such as: "The sickness experience of the tonsillectomized group was no better than that of children in whom there had been no operation." He points out that there are some serious fallacies in such a conclusion.

1. Tonsillectomy is very frequently incomplete. Some of the largest and most septic tonsils are to be found in children who have had their tonsils "removed." Many studies, therefore, merely compare the health of children whose tonsils were never removed with that of children who, in spite of operation, still have septic tonsils.

2. It is obvious that in the tonsillectomized group there must have been some sort of reason for the operation, such as recurrent colds or coughs. It is a fair assumption that in a high proportion of the nontonsillectomized group there was no such condition. It is, therefore, meaningless to compare the health of one group after the operation with that of another more healthy group which had no operation.

3. Sinus infection is very frequently the cause of the symptoms for which the tonsillectomy is (wrongly) advised. The symptoms and effects of sinus infection are not relieved by tonsillectomy. Studies of the effect of tonsillectomy without the elimination of a possible sinus infection are valueless.

4. Important causes of the apparent failure of the operation are: *a.* persistence of hemolytic streptococcal infection in the throat, shown by Kaiser and others to be common; and *b.* a common complication of tonsillectomy — infection of the nasal sinuses. Studies of the subsequent health of tonsillectomized children, with very few exceptions, do not take these factors into account.

The many large scale studies which he has read are as fallacious to his mind as would be the comparison of the health

of a group of patients who had had no stomach operation with that of a group which had had an unspecified operation on the stomach for unspecified symptoms and disease, with unspecified complications and associated infections, and without mention of the completeness or otherwise of the removal of gastric or malignant tissue. What is required is a large scale study of the health of children who, having no pre-existing or complicating sinus infection, have had, for specified conditions such as nephritis or recurrent colds, a tonsillectomy completely and correctly performed, with elimination of the pre-existing infection, as compared with the health of a similar group of children who, with the same condition, chose to keep the tonsils in and rely on medical and general treatment only. He looks forward to seeing such a study.

In addition, it would be interesting to compare the disease experience of children who have had an unsuccessful tonsillectomy, which has failed for the reasons mentioned, with that of children in which the operation was "successful." A mere investigation of the frequency of disease before and after tonsillectomy is fallacious for another reason — the fact that the child is older after tonsillectomy than before it, with all that that implies in altered environmental and other conditions.

Layton[31] believes that the operation of tonsillectomy and adenoidectomy should be performed only when an adequate history and clinical examination have revealed the necessary criteria. He does not believe that any mother should ever be expected or allowed to hand over her child for this operation with its attendant dangers after less than a quarter of an hour's discussion with the surgeon. He further believes that if the surgeon gives that amount of time to each case he will cut down considerably the number in which he advises operation. He notes that it is a remarkable thing that when an operation has been advised, the administration will always find the time, accommodation and personnel for its performance, but that no such administration has yet been set up which will give that minimum of a quarter of an hour between the parent upon whom the responsibility for decision rests

and the surgeon in whose hands the responsibility for advising the operation is finally put.

Capps and Gwynne-Evans[32] reply to the foregoing comment that such an administration has been functioning in a general hospital for some time. Here cases may be reviewed weekly or monthly by a team of workers whose aim is a fuller comprehension of the functional efficiency of the entire respiratory tract with an attempt at classification of criteria whereby the operation of tonsilloadenoidectomy may be considered justifiable and good results reasonably expected.

Howard[33] endeavors to answer the often asked question, "Will my child get poliomyelitis if you take out his tonsils and adenoids during the poliomyelitis season?" Both pediatricians and throat specialists have been confused in knowing the correct answer.

Occasionally there has been a serious relationship between poliomyelitis and tonsillectomy. Many authors have shown from their reports in the literature that there is a real hazard when poliomyelitis does complicate a simple tonsil and adenoid operation. In consequence, the procedure of postponing tonsillectomy in the presence of an outbreak of poliomyelitis is now becoming common.

To answer the question, he studies statistics from Cincinnati. During the seven-year period from 1937 to 1943, inclusive, there were 36,295 tonsil operations performed in the hospitals of Cincinnati, of which 23,442 were tonsil and adenoid operations on children of the age most susceptible to poliomyelitis. This averages 3,348 tonsillectomies on children performed in hospitals per year of a population of approximately 500,000. Of this 3,348, an average of 1,851 tonsillectomies and adenoidectomies are done yearly in Cincinnati during the months when poliomyelitis occurs — July, August, September and October.

The latter months are the popular months for the operations because of vacations and freedom of the patient from upper respiratoy infection; in the remaining eight months, one postpones at least one-third of the operations on account of colds, sore throats and ear infection. The question, there-

fore, arises, which is the more dangerous, in years in which there is no epidemic of poliomyelitis, to take the risk of a tonsillectomy and adenoidectomy during months when poliomyelitis most frequently occurs, or to postpone the operation to months when poliomyelitis is minimal and colds are prevalent?

During the seven-year period there have been 257 cases of poliomyelitis, of which 233 have occurred in the four months, July to October, and the remaining 24 cases mostly in November. In this group only six cases of poliomyelitis developed following recent tonsillectomies and adenoidectomies. These operations were performed 10 to 21 days previous to the development of initial symptoms of poliomyelitis. Three spinal and three bulbar cases resulted, with one bulbar death and five recoveries with minimal paralysis. The approximate ratio of poliomyelitis to tonsillectomies is one to 2,000 and to the total number of cases of poliomyelitis during those months, one to 40.

The organism causing poliomyelitis is a filterable virus and may be present on any surface of the gastrointestinal tract from the lips to the lower bowel of persons afflicted with the disease, convalescent or associating with carriers. The incidence of cases in widely separated parts of the nation with no particular connection indicates that the virus is widely distributed among normal people and manifests itself only in those who are susceptible. The infection may be transferred by the hands, handkerchiefs and towels, and spread by coughing, sneezing, loud talking or laughing.

Numerous examinations of the olfactory bulbs of patients who have died of poliomyelitis have failed to demonstrate, except in a few instances, the virus or its inflammatory reactions in this bulb. The consensus of opinion regarding the portal of entry at the present time is that the virus enters through the mucous membrane of the alimentary tract, upper, lower, or both.

He concludes: *1.* the possibility of poliomyelitis during July, August, September and October in nonepidemic years following tonsillectomy is minimal, but when it does occur

it is serious and most often bulbar in type; *2.* the possibility of poliomyelitis following tonsillectomy in the other eight month is *nil*; *3.* preventive measures as produced now by Boards of Health throughout the United States show that during months and years when there are epidemics of poliomyelitis, operations on the nose and throat should be avoided whenever possible for the safety of patients.

The possible relationship of poliomyelitis and tonsillectomy is of such importance that Page[34] used the records of the Manhattan Eye, Ear and Throat Hospital to obtain facts.

The Department of Health of the city of New York reported the number of cases of poliomyelitis that occurred in the five years from 1937 to 1941. As 1937, 1939 and 1941 were the years in which the disease was conspicuously most prevalent, the patients who had tonsillectomies performed on them during those years were communicated with by mail. Twenty-seven thousand eight hundred forty-nine cards were sent out by the Manhattan Eye, Ear and Throat Hospital requesting that answers to questions be written on a return postal card. A total of 8,915 replies were obtained, and only one of these reported the occurrence of poliomyelitis (about one month) after the removal of tonsils and adenoids.

Lucchesi and La Boccetta[35] studied the question whether the presence or absence of tonsils has any relationship to the type or mortality of poliomyelitis. In the years 1937-1942, 432 patients in the Philadelphia Hospital for Contagious Diseases with the diagnosis of acute anterior poliomyelitis were investigated. Their evidence makes them believe that the absence of tonsils and adenoids increases the risk of bulbar involvement in persons with poliomyelitis. They are, therefore, against the indiscriminate removal of tonsils and adenoids.

Grant[36] reports what he believes to be the first use of hydrostatic pressure to control severe adenoid hemorrhage.

A normal boy, age six, after removal of tonsils and adenoids, left the operating table with what was thought to be the usual oozing from the nasopharynx. That evening nasal packing seemed indicated.

The following morning there was marked pallor and signs of continued bleeding. Anterior and postnasal plugging was resorted to with only

temporary success. The hemoglobin dropped to below 50 per cent and the outlook became serious. Blood transfusion was ordered and the patient returned to the operating room, where the source of the bleeding was located in a sulcus at the center of the adenoid site. This seemed to lead directly into the basilar process. Firm pressure controlled it, but after one-half hour the bleeding recurred when pressure was released. Then hydrostatic pressure was used. With a long needle, about 20 cc. of physiological sodium chloride solution was forced into the mucous membranes above and at the side, which ballooned the entire area together. All bleeding stopped instantly and there was no recurrence.

MacGregor and Long[37] have proven that pencillin included in a pastille under suitable conditions of manufacture is liberated in the mouth in an active form. The concentration in the mouth can be maintained and the pastille kept for a period of at least three months without appreciable deterioration or loss of efficiency of the penicillin. It is simple to use and is well tolerated even by children. (The youngest patient receiving pastilles was aged five.)

Acute ulcerative gingivostomatitis (Vincent's type) can be treated more simply and more quickly with the use of penicillin pastilles than by any other method. In addition, the loss of tissue caused by the more usual treatments with caustics and escharotics can be avoided. It is not suggested that gingivectomy or other procedures to eliminate the gum pockets and stagnation areas will not be necessary at a later date, since, while these pockets and areas remain, the possibility of recurrent infection is always present. The treatment described is advocated in the acute stages, and the fact that no recurrences have been seen over a period of three and a half months suggests that immediate recurrence is unlikely. In view of the fact that intravenous arsenicals are still widely employed in the treatment of the disease in spite of much evidence to show that it is ineffective, they consider it is worth drawing attention to the fact that three of their most severe cases have been undergoing treatment for syphilis with injections of bismuth and intravenous arsenicals.

Patients with acute hemolytic streptococcal tonsillitis, including four with scarlet fever, seemed to respond clinically to treatment with pastilles. The effect on the throat flora appeared to be rapid, but even so, a larger series of cases is necessary before any final conclusions can be drawn. The early disappearance or reduction in numbers of hemolytic

streptococci in the throat after treatment had started suggests that the risk of droplet infection is greatly reduced and they regard this point as of importance epidemiologically.

The treatment of throat carriers of hemolytic streptococci proved disappointing, as was anticipated; nevertheless, it is of interest that they became negative while undergoing treatment.

In the small series of patients so far treated, it appeared that surgical conditions of the mouth and throat could be kept free from pathogenic organisms during administration of the pastilles, with marked symptomatic relief.

On bacteriological grounds, faucial diphtheria should be an indication for treatment with penicillin pastilles. Unfortunately, they have as yet been unable to obtain suitable cases, but it is hoped to publish these results later in a fuller report.

ATROPHIC RHINITIS.

The *Journal of the American Medical Association,*[38] replying to the question whether anything new is in use in the treatment of the untractable cases of atrophic rhinitis, states that a series of researches has been undertaken in recent months on the effect of implants of estrogenic substances but the results have not justified the use of such measures. Most rhinologists adhere to the fundamental principles of general and local treatment. The local measures are many and the best results are obtained when they are varied from time to time. They consist in cleansing the nasal fossae of crusts and secretions and stimulating the mucosa to function better.

SURGERY.

Salinger[39] believes that, although the technique of submucous resection of the nasal septum is on the whole adequate, unsatisfactory results in certain types of cases have led to a partial revision of our ideas on the subject and to a number of modified procedures. The object of these newer procedures is not only to relieve the patient of his nasal obstruction, but at the same time to prevent distortion or collapse of the nasal tip and to correct such concomitant

deformities as may be in intimate association with the deviation.

He states that a great many of the irregularities are the result of trauma, recent or ancient, and, therefore, if we are to restore the nose to its normal status, we must consider first the primary treatment of injuries to the nose as a prophylactic measure, and second, the actual treatment of such deformities where primary treatment has been inadequate.

Trauma to the nose is exceedingly common for obvious reasons, but unfortunately unless it is severe, it frequently is overlooked or neglected. This is particularly true in children who sustain innumerable falls when learning to walk, and later at play. Even minor trauma at this stage may have serious consequences because of the immature state of the constituent nasal framework, since ossification is not complete until after puberty. The nasal bridge and the septum, being partly cartilaginous, fail to fracture completely. Instead, they may bend or curve slightly as a result of injury and continue then to develop into a deformity which becomes fully manifest only in later years. A child whose nose has been injured sufficiently to cause an external swelling, bruises or hemorrhage followed by nasal obstruction should be carefully examined, under a general anesthetic if necessary. The septum and the turbinates should be adequately shrunk with adrenalin and cocaine, and examined for the following: subperichondrial hemorrhage, lacerations of the mucosa, suspicious bends or malposition. When the septal cartilage is dislocated from the vomer groove it can be easily corrected; however, if the condition has existed for more than a week he finds it very difficult to set the cartilage back in the groove because of the interposition of newly developed fibrous tissue.

Hematomata are quite common and should be thoroughly evacuated. It is true that in many cases infection will not take place and the blood clot will be absorbed. It is not feasible, however, that one run the risk, knowing the destructive effects of a septal abscess, particularly in a child; besides, there is no question in his mind that the organization of the blood clot leads to fibrosis and interferes with the further growth of the cartilage. It is advisable, therefore, to incise

the mucous membrane, evacuate the clot and then pack firmly to prevent further bleeding. The treatment, here, parallels that of hematoma of the auricle.

Where the septum is found to be bent or curved, it may or may not be associated with a depression of the nasal bridge, the nasal bones being crowded between the ascending processes of the superior maxilla. X-ray examination may be helpful in determining this question, but external palpation is generally sufficient. In such cases it will not be possible to eliminate the septal curve without at the same time elevating the nasal bridge. This is accomplished by intranasal pressure with a heavy, dull elevator or an instrument which he designed for this purpose. The septum can then be pushed back into place and retained by means of packing or a wax plug. In some of these cases it is necessary to apply a copper molded splint over the nasal bridge to overcome the spreading tendency and reshape the immature bones.

Eisenstodt[40] states that it frequently has been necessary to perform a secondary submucous resection and he described the technique adopted at the New York Post-Graduate Medical School and Hospital. In nine instances the cartilaginous and bony septum was found intact. He concludes from this that each of the two mucoperichondrial flaps independently is capable of chondrogenesis and the formation of a separate septum providing the other flap is intact.

From this he argues that more children with severely deflected and fractured septa should be operated upon than is the present custom, both from a functional and cosmetic point of view. Most otolaryngologists defer septal operations until the age of 16. He, however, gives evidence that a conservative submucous resection in a child will not interfere in any way with the normal growth of the nose. He feels justified in stating that the chondrogenic power of the perichondrium is even greater in the young, and that the septal regeneration progresses to a much greater degree than in the adult.

Ersner[41] argues that during parturition, difficult or painful labor may give rise to many nasal injuries. He recognizes

that, although pressure during delivery causes many infants to be born with flattened noses, the same noses often eventually become straightened and elevated. Such a happy outcome is not to be expected if, during birth the cartilaginous portion of the nasal septum is dislocated from the groove of the vomer. This, he states, is the most prevalent injury to the nose of the newborn and gives rise in later life to a deflected septum with resultant impaired nasal respiration and perhaps the external deformity of an asymmetry, a concavity or a hump.

It should be a routine practice for every obstetrician to inspect and palpate every infant's nose for septal deflections or nasal anatomical dislocations and fractures, just as routine examinations are conducted to determine the presence of any other deformities or injuries.

Such deformity should be corrected immediately before green-stick fracture develops or a callus forms. One has only to grasp the tip of the nose with the thumb and index finger, gently but firmly pulling it from side to side, or tugging the tip of the nose slightly ventrally. One can usually feel or even hear the snap of the reduced dislocated cartilage.

Imperatori,[42] in a profusely illustrated article, describes a Mackenty operation upon a child, three and one-half years old, who had atresia of the pharynx. The chief symptoms were slight difficulty in swallowing, noisy breathing, inability to breathe through the nose, and "a muffled voice," developing shortly after an operation for removal of tonsils and adenoids. Examination showed "a web" of scar tissue extending from the hard palate downward to the posterior wall of the lower part of the oropharynx, including the soft palate and the uvula. At the lower part of this web, near its junction with the pharyngeal wall, there was a small fistula. Operation was done by the procedure described by Mackenty; postoperatively, the opening was dilated with a Kelly clamp, the ends of which were covered with rubber tubing, first at weekly then at monthly intervals. The child's condition is good, with satisfactory gains in height and weight. In a review of the records of the Manhattan Eye, Ear and Throat Hospital, where approximately 100,000 adenoid and tonsil operations

have been done in the past 10 years, only three cases of atresia of the pharynx were found and the condition followed an adenoid and tonsil operation in only two of these cases; in these two cases the Seton type of operation was done. In the third case the atresia was due to a severe throat infection.

TUMORS.

Hara,[43] in a comprehensive and well illustrated article on ossifying fibroma of the superior maxilla, reports such a growth in a 14-year-old white boy and its treatment. This was diffuse and was curetted sufficiently to give its bony bed a normal contour. No attempts were made to remove the portion which infiltrated the dental roots. The advisability of instituting radiotherapy for the unresected portion of the growth was discussed with those in charge of the tumor clinic. The radiologists felt that in view of the age of the patient the possible danger to his teeth might outweigh the benefit from such treatment. Some months later, there was definite regression of the growth.

Adams[44] reports in detail an osteoma in the left ethmoid of a 13-year-old boy. Five illustrations.

The patient was first seen in August, 1942, suffering from a left-sided exophthalmos. In the previous January he had received a blow in the left orbit from a snowball. When the bruising and swelling subsided, the left eye was proptosed and pushed outwards in the orbit. There had been no further displacement, and no pain or headache. He was able to read a newspaper with either eye. In the left eye exophthalmos was present without signs of inflammation. The lid closed completely. Fundus and disc were normal. A small, hard nodule was felt at the left inner canthus, and X-ray showed an osteoma in the left orbit. Operation was advised against in view of the likelihood of extremely slow growth and the absence of complications.

In March, 1943, the proptosis and lateral displacement of his eyeball had increased and the globe was also pushed slightly downwards. A hard, bony mass was palpable on the inner side of the left orbit. There was no diplopia and no loss of vision. X-ray showed the osteoma had increased greatly in size. In view of its rapid growth, operation was advised before complications should supervene.

It was thought that a transfrontal approach would be unlikely to succeed in more than fragmentary removal, while an anterior approach reflecting the external nose was open to the objection that free access to the posterior part of the tumor would not be possible. It was realized that the tumor might be densely attached to an inaccessible bony plate such as the horizontal plate of the frontal, that its size might prevent delivery and that there was risk of damage to the left optic nerve and of a tear in the dura of the anterior fossa.

Removal of a large part of the anterior face of the left maxilla showed the tumor presenting into the upper medial angle of the left antrum along its whole length. The medial wall of the maxilla was then removed and part of the attached margin of the left nasal bone. A blunted, curved septal elevator was passed between the tumor and the orbit, and then between the tumor and the soft tissues anteriorly and then posteriorly. It was then possible to grasp the tumor between the blades of the Dennis Brown adenoid tag forceps, one blade in the nasal cavity and the other between the tumor and the orbit. Ultimately the tumor was rocked free from its bed. The main difficulty in its release lay in obtaining air entry around the tumor to allow its displacement from the bed in which it was very firmly held by negative pressure. Hemorrhage was at no time troublesome. Antiseptic packing was inserted into the tumor cavitv and brought out through the anterior naris. The sublabial incision was then closed. Recovery was uneventful.

The tumor measured 2 inches by 1½ inches by 1 inch and was an ivory osteoma.

In the year following removal, the patient's progress has been satisfactory and his eye displacement has disappeared. Follow-up radiographs have shown no sign of recurrence of the tumor. No radiation therapy has been considered necessary.

Mollison[45] reports the following case of ethmoidal growth not only because operations combined with radiation cured it, but that the type of growth changed in the course of a few years.

A girl, E. B., aged 12, was seen in 1926; before this, the tonsils and adenoids had been removed; discharge of mucopus continued and epistaxis occurred daily; the bridge of the nose was broadening and the girl had epiphora on the left side.

Examination of the nose showed a large pink mass on the left side and a diagnosis of ethmoidal growth was made. Operation was performed through a nose to ethmoidal incision; the growth occupied the whole ethmoidal labyrinth and was invading the antrum; the frontal sinus contained mucopus. Section was examined by Prof. Nicholson, who reported small round-celled sarcoma. Three months later was well, no growth, only a large crust which was kept at bay by douching.

The patient remained free from growth for three years; then a recurrence was removed and radium needles inserted.

Prof. Nicholson now reported the growth was a cellular basal-celled carcinoma. Further recurrence occurred and in January, 1930, a further operation was performed; there was much bleeding and the mass was removed from the ethmoid and from the upper part of the antrum. Section now reported as a neuroblastoma with attempts at differentiation into glia; it was infiltrating widely and freely.

In March, 1930, a piece of tissue removed from the nose was reported on as follows: edematous cellular granulation tissue, no new growth.

Recovery satisfactory. Subsequently, occasional attacks of frontal sinus retention.

No recurrence occurred. The patient was seen in 1933, 1935 and 1944

and remains well, except for mild attacks of retention in the frontal sinus. She married and has a child.

Foster[46] reports a congenital nasopharyngeal dermoid in a well nourished, healthy 19-day-old infant.

The mother said there had been some obstruction in breathing since birth and that in a short time she noticed that the infant got something in its mouth and suckled on it. On depressing the tongue, a rounded tumor was visible attached to the posterior pharyngeal wall. It was freely movable on a small pedicle and at times disappeared into the nasopharynx; at others, it came into the mouth. The tumor was grasped with forceps and removed with a snare. There was no bleeding of any consequence. Three illustrations.

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AMERICAN BOARD OF OTOLARYNGOLOGY.

The Chicago meeting of the American Board of Otolaryngology scheduled to be held in October, 1945, has been cancelled. The next examination will be conducted in the spring, the exact time and place to be announced later.

REACTION OF THE HUMAN CONDUCTION MECHANISM TO BLAST.*†‡

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The large number of clinical reports[1,2,3,4] on acoustic trauma that have originated in the military service during the last few years emphasize the importance of this problem to the otologist. The most injurious noises are explosive in type. While the clinical picture of acoustic trauma from these noises is well defined, the fundamental reactions between the stimulus and the ear are obscure. This is in part due to the difficulty in studying the effect of explosive phenomena on the ear. The nature of the stimulus itself is difficult to understand.

When T.N.T. ignites or explodes, it changes from a small volume of solid to a large volume of gas in about 10 microseconds (1/100,000 second). The molecules of surrounding air are highly compressed by this almost instantaneously created gaseous sphere of the explosive. After this exceedingly rapid and great rise in pressure, the air molecules regain normal pressure relationships. This occurs at a much slower rate; zero pressure is regained in about 1/1000 second or more. There follows a still longer but weaker phase of negative pressure lasting over 1/100 second and then normal pressure relationships between the molecules of air are regained. This asymmetrical pressure wave is propagated from one spherical layer of molecules to the next essentially like a sound wave, each molecule oscillating about its resting position. The speed of propagation of this wave is similar to that of an ordinary sound wave except near its point of origin. For a short distance near its source the wave is propagated more

*Presented in part at the American Academy of Ophthalmology and Otolaryngology, October, 1942.

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‡This work was aided by a grant from the Douglas Smith Foundation for Medical Research of the University of Chicago.

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, June 25, 1945.

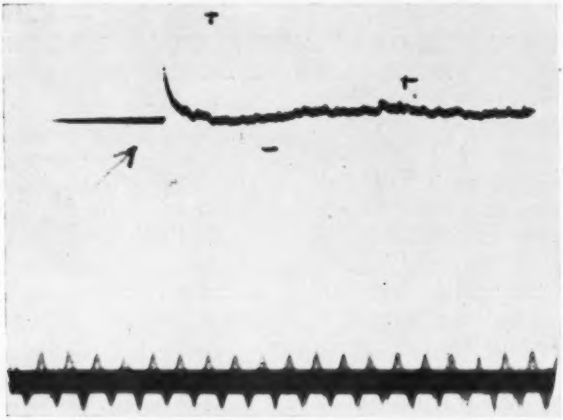

Fig. 1. Pressure to time relations of a typical shock pulse from a powder blast. Timing wave 1,000 cycles per second.

rapidly than 1,100 feet per second and great dynamic pressure is developed. The pressure wave initiated by an explosion is called a "shock pulse" (see Figs. 1 and 2), and can be defined as a sound wave of great condensation and great

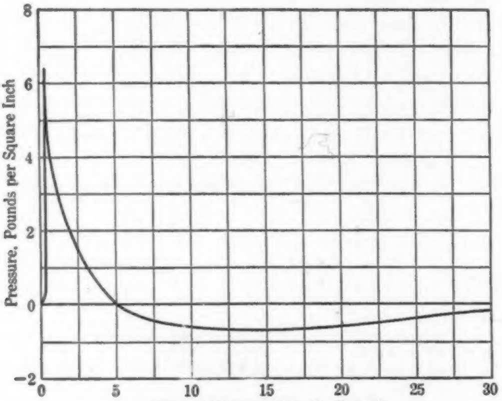

FIG. 6.—Shock-wave pressure vs. time.

Fig. 2. Record from 500-pound bomb at 50 feet.

initial velocity. Ordinary sound waves are characterized by an equal average of molecular compressions and rarefactions. To be heard, these pressure changes must occur within an interval of time between 1/20 and 1/20,000 second. The ear will respond to pressure changes as small as 1/5 billionth of an atmosphere. The pressure changes occurring in a shock pulse are infinitely greater, especially where the pulse is traveling with a velocity greater than sound, and vary also with the amount and type of explosive. Near its source the inten-

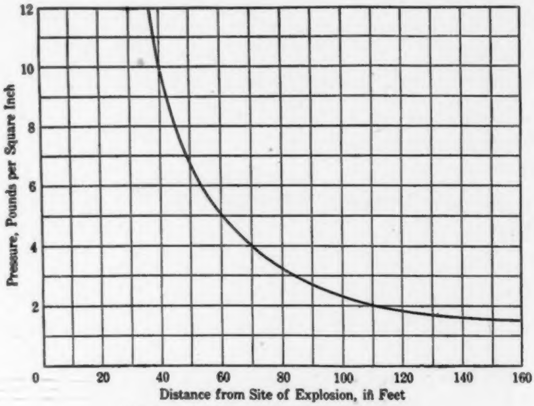

FIG. 7.—Shock-wave pressure vs. distance.

Fig. 3. Record from 500-pound bomb; at the site of detonation the pressure was probably over 100,000 pounds per square inch.

Figs. 2 and 3 from: Explosions—C. C. Robinson Courtesy, McGraw-Hill Book Co., New York, N. Y.

sity falls off more rapidly than inversely as the square of the distance (see Fig. 3). In water the intensity is not dissipated so rapidly. Nine ounces of gun cotton exploded under water can be recorded 40 miles away. Injury to the ears by a shock pulse propagated under water has been reported.[5]

Variations occur in the speed of pressure changes in a shock pulse, depending on their source. Gun powder burns more slowly (has lower brissance) than T.N.T. (high brissance). This will result in a difference in the auditory sensation of the resulting shock waves. The only reason that the ear responds to these pressure waves is because they occur

within a period of time to which the ear can react. The peripheral ear can be considered as a mechanism made to respond to pressure changes occurring within certain time intervals (about 1/20 to 1/20,000 second). If a pressure change occurs during a longer or shorter interval than this, no localized sign is created at the end-organ and hence there is no auditory sensation. The peripheral mechanism responds to single asymmetrical pressure disturbances as well as to sustained symmetrical pressure disturbances. When the latter reach the ear at the rate of 1,000 per second, they are

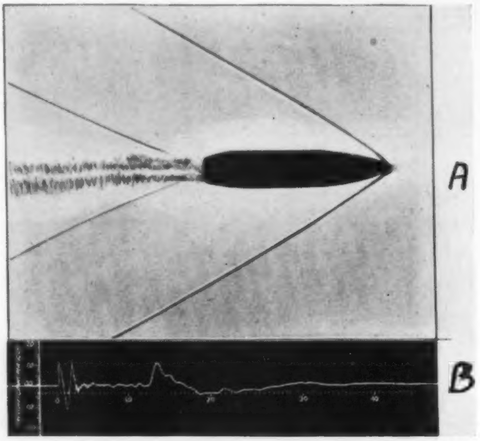

Fig. 4. The shock pulses arising from nose and base of bullet (A) traveling at supersonic velocity may be as intense as the shock pulse from the powder blast at the muzzle of the gun (B). (Miller, D. C.: Sound Waves. Courtesy: The MacMillan Company.) Time interval, 0 to 10 = 1/10 second.

sensed as a 1,000 cycle tone. When the former single disturbance strikes the ear it is sensed as a crack, bang or click, etc. When the rise in pressure is very abrupt it may be described as a crack. If the rise is slower it may be sensed as a boom, pop or bang. Other changes in the auditory sensation occur as the result of reflection and variations in intensity of a pulse. It is interesting to note that Steudel[6] found that the shape of a pulse wave up to 0.3 millisecond has little to do with the sensation of loudness. In gunfire the shock pulse occurs as the result of uncorking of the burned

gases in the barrel by the departing bullet. Two additional shock pulses are developed by the bullet because it travels at supersonic velocity[7] (see Fig. 4). Secondary oscillations set up in different sized gun barrels are important in modifying the total acoustic sensation. If the pressure of the pulse is great enough, even if it is very slow, gross damage to the conducting mechanism may result. Sustained pressure of 200 to 400 mm. Hg. is sufficient to rupture the drum.

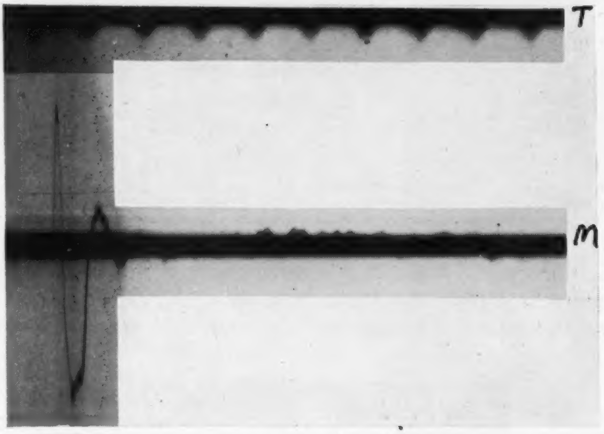

Fig. 5. Oscillation of the human conduction system at the malleus (M) in response to a shock pulse initiated at the open external canal (T). One thousand cycles per second timing wave.

Knowedge of the physical properties of the ear is necessary if one is to understand how it responds to a shock pulse. The conducting mechanism is not made to follow accurately a pressure change of 1/100,000 second (10 microseconds) duration but reacts like a ballistic receiver. Such an abrupt wave front can be analyzed into a continuous spectrum of acoustic energy. The ear acts like a wave analyzer and ballistic receiver and follows the pressure rise in a manner that depends on the frequency and intensity of the various components and upon the physical properties of the ear itself. The malleus head is displaced to a maximum positive position in about 25 microseconds, or 1/4000 second (see Fig. 5). The drum and attached chain is then exposed to the slower return

to normal pressure and the following still slower period of negative pressure; however, the major disturbance set up in the conducting mechanism by a shock impulse generated at the external canal as recorded from the head of the malleus

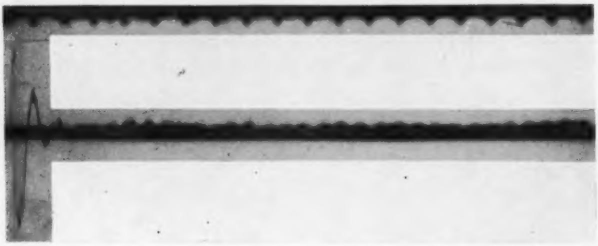

Fig. 6. Typical response of the human conduction mechanism at the malleus in response to a shock pulse delivered at the open external canal. Note that the first part of the oscillation is more rapid than the second part and that the principal reaction is over in less than 1/1000 second.

consists usually of a single asymmetrical rapid oscillation (see Figs. 6 and 6A). The main wave is many times greater in amplitude than the succeeding ones and is, therefore, the most important traumatizing factor. This main oscillation

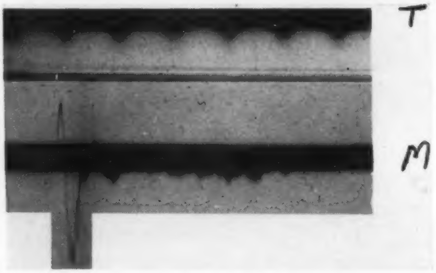

Fig. 6A. Malleus response. Shock pulse at the open external canal. (T) 1,000 cycles timing wave. Note the high frequency and asymmetry of the large initial oscillation. The positive phase is above the base line.

lasts about 1/1000 second and is the direct resultant of the interaction between the shock pulse and the ear.

Analysis of this single large malleus oscillation reveals that the greater movement is on the negative side of the resting position. This larger negative wave is also slower than the

positive phase. This increase in duration is probably due to the corresponding slower return from the position of maximum pressure of the shock pulse. The increase in amplitude of the negative phase of malleus movement is due to the asymmetry of malleus movement to positive and negative pressure. For a given amount of static and acoustic pressure, movement outward of the malleus head (positive phase) is smaller than movement inwards (negative phase). Another factor that must act to progressively reduce the speed of the initial large oscillation is the natural frequency of the conducting apparatus which is lower than the speed of the pressure change in the positive phase of the shock pulse (see Fig. 7). A factor that limits the duration of the response of the middle ear to this shock pulse is the high degree of damp-

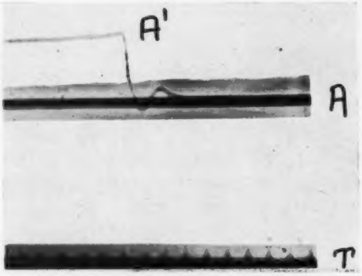

Fig. 7. Record showing the resonance frequency and damping characteristics of the human conduction apparatus.

When the displaced malleus (A') in an intact ear is allowed to come to rest (A) in its own manner, it swings to the opposite side of center but once, and comes to rest in about 1/700 second. (T) is a 1,000 cycle timing wave.

ing or resistance of this mechanism. This insures an abrupt cessation of movement after the external force has been spent, as the records show. These important properties (damping and resonance frequency) of the malleus in the intact chain can be determined on fresh temporal bones by displacing the chain with a fine hook and recording the movement of the malleus as the hook is released and the chain returns to its position of rest (see Fig. 7).

The reaction of the intact conduction apparatus at the stapes was recorded by a mirror fastened to the vestibular

surface of the footplate. As the shock pulse reaction is propagated along the conducting mechanism it is reduced in amplitude and changed in shape. As would be expected, the amplitude of movement of the stapes footplate is much less than that recorded from the head of the malleus, but in addition an important change occurs in the shape of the movement.

Fig. 8. Stapes oscillation to shock pulse at the external canal. Major oscillation is negative of center and lasts about 1/1000 second.

Compare amplitude with that from the malleus (see Figs. 5 and 6).

The positive pressure phase of the disturbance has been largely eliminated now by differential movement between the ossicles and the principal pressure change is negative (see Figs. 8, 9, 10 and 11). This largely negative oscillation resembles that produced by physiological stimuli of sustained sound waves. These observations indicate that the effect of

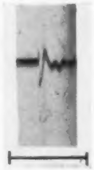

Fig. 9. Stapes oscillation to shock pulse. Note major oscillation is negative of center and lasts about 1/1000 second.

Also compare amplitude with that from malleus (see Figs. 5 and 6).

the positive pressure wave of the incoming shock pulse is largely dissipated by the time it reaches the end-organ and that the important traumatizing effect to the end-organ comes from the negative phase of the induced oscillation.

The preceding analysis is presented to point out the acoustic properties of the shock pulse and of the conducting mechanism and how the external stimulus reacts on this part of

the ear to produce a local sign that is delivered to the end-organ. To obtain some perspective on the magnitude of pressure changes in the blast wave or shock pulse, one should review the sensitivity characteristics of the ear to ordinary sound. One can hear a 1,000 cycle sound wave whose effective pressure is 0.0002 dynes per sq.cm., or less than a billionth of an atmosphere. When the effective pressure exceeds about 1,000 dynes, the sound becomes painfully loud. Ordinary con-

Fig. 10. Stapes oscillation to shock pulse. Chain intact. Mirror in foot-plate.

Note that major disturbance is negative of center and lasts about 1/1000 second.

versation is carried on with effective sound pressures of about 1 dyne per sq.cm., or one-millionth of an atmosphere. The pressures developed in a shock pulse or blast wave are usually much greater than in the loudest sustained sound; indeed, they may be several atmospheres. Thompson[8] measured the intensity of a shock pulse from 10 pounds of T.N.T. at a distance of 26 feet. The intensity was computed as 10^4 watts per sq.cm. — about 200 db. above the threshold for hearing of sustained sound. In gunfire the intensity of the

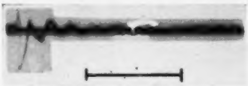

Fig. 11. Similar to Figs. 8, 9 and 10.

pulses developed from the uncorked gases at the muzzle and from the bullet itself are also large (see Fig. 4). They may reach the ear so close together as to be heard as a single bang when one is near the gun, or the pulses from the bullet may be heard separately from that of the exploding gases at the muzzle when one is near the trajectory. In any case, all the pulses react upon the ear. For large guns or explosives, the pressures developed at certain positions may be many atmospheres and are incompatible with life. Positions in form of a

line across the muzzle of a gun are dangerous; but even at positions behind this line, the pressures delivered by the pulse are very great, acoustically speaking, and can cause acoustic trauma.

The reaction of the shock pulse with the human conducting mechanism was investigated on fresh temporal bones. The experimental arrangement is diagrammed in Fig. 12. The elasticity of the conducting elements in a fresh preparation

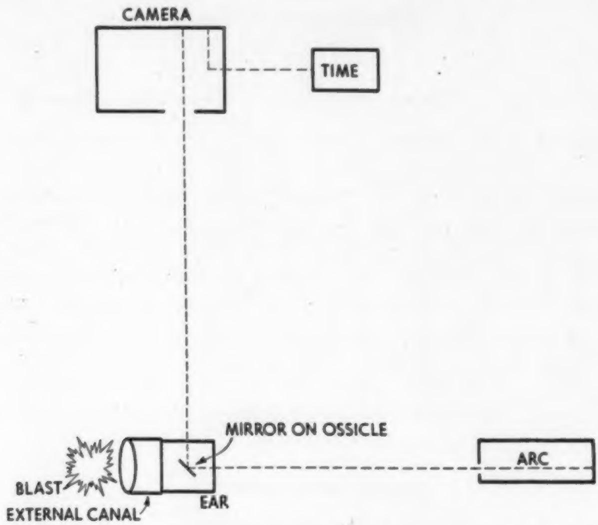

Fig. 12. Diagram of arrangement of experimental equipment for recording movement of the ossicular chain induced by blast.

is about the same as that of the living ear. The middle fossa plate was removed to allow placement of a tiny mirror (.0.015 x 0.03") on the head of the malleus. The light of an arc was reflected from this mirror into a camera. The short distance of the mirror to the axis of rotation of the malleus as compared to the distance of the mirror to the film resulted in an optical magnification of about 200. By much experimentation, an adequate practical source for the blast wave was found — a pulse strong enough to produce a good oscillation at the head of the malleus. The source was a 32-calibre blank

cartridge exploded from a starting pistol held near the external auditory canal of the preparation. At this position the induced oscillation of the head of the malleus as recorded on the film at a magnification of about 200 was about one inch wide. A similar amplitude of displacement could be obtained with a static pressure of several centimeters of water. The movement of the stapes footplate was also recorded. This was accomplished by exposing the vestibular surface of the footplate and fastening a similar mirror to it. This mirror covered about one-third of the area of the footplate. In studying the reaction of the human conducting mechanism to the blast wave, one is led to consider the way in which the peripheral ear is naturally protected from damage by such unphysiologic stimuli.

The conducting elements are partially protected by being physically unable to follow faithfully a pressure change occurring in 10 microseconds. Another natural protective device lies in the particular manner of action of the ossicular chain. The positive phase of both a pure sound wave and of the shock pulse tends to be largely eliminated as it travels along the ossicular chain by differential motion at the incudomalleolar and incudostapedial joint and by the resistance of the annular ligement. The record shows that the principal oscillation delivered to the end-organ by the stapes footplate is largely negative in phase. Bekesy[9] holds that for very great sounds the axis of stapes movement is through the long diameter of the oval window as contrasted to a normal axis at right angles to this and near the posterior lip of the footplate. The stimuli used in our experiment — both shock pulses and sustained sound waves — did not produce a change in the axis of stapes movement.

At this point one may profitably consider the effect of drum rupture by blast on the strength of the stimulus arriving at the end-organ. Preceding observations on the differences in movement of malleus and stapes may indicate an explanation for the clinical observation that rupture of the drum appears to have a protective effect on the end-organ (see Fig. 13). The great pressure rise of the shock pulse can rupture the drum. The drum is now much less effective as a driving sur-

face for the chain. The return to normal pressure and the succeeding negative pressure of the shock pulse produce much less movement of the now perforated drum and the attached chain, hence these immediately succeeding pressure changes produce a smaller negative displacement of the stapes. It is this negative displacement that is the principal force nor-

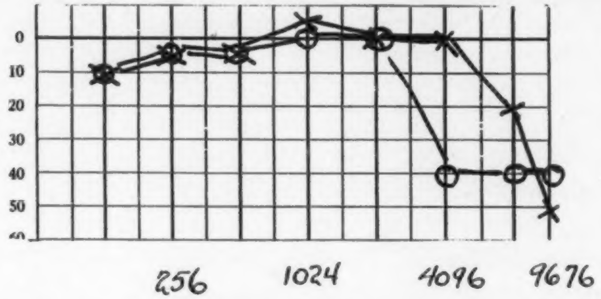

Fig. 13. x———x — right; 0———0 — left.
Audiogram following blast injury with small perforation of the right drum. Note smaller amount of acoustic trauma on side of perforation.

mally acting upon the end-organ. Experimentally it can be shown that a perforated drum results in a reduction in the amplitude of an induced movement of the ossicles to large stimuli.

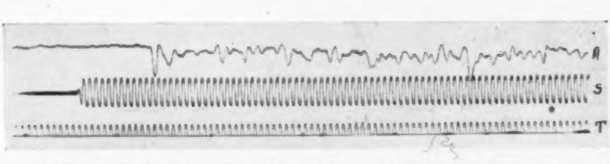

Fig. 14. Record of the action potentials. (A) from the human stapedius muscle in response to a 1,000 cycle tone (S). (T) is a 1,000 cycle timing wave. Noe about 10 cycle (1/100 second) lag between onset of sound and onset of action potentials.

Another physiological mechanism of the ear must be considered in this problem of protection from the effects of a shock pulse: the action of the middle ear muscles. Experiments in man, animals and on fresh temporal bones leave no doubt that contraction of the stapedius and tensor tympani muscles reduce the amplitude of oscillation of the chain and act particularly upon the important negative phase of the movement; however, a certain time must elapse between the

arrival of the first sound wave to the end-organ and the propagation of the nerve stimulus through the brain stem and to the middle ear muscle. This time interval had been

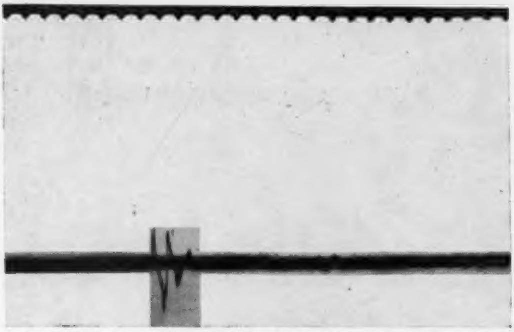

Fig. 15. Reduction in amplitude of malleus motion with increased distance (15") from blast. (T) 1,000 cycle timing wave at top of figure.

previously measured in man,[10] using an electrode on the stapedius tendon and a stimulating tone of 1,000 cycles. A latent period of about 10 milliseconds was found (see Fig. 14). Since the principal oscillation induced by a shock pulse lasts

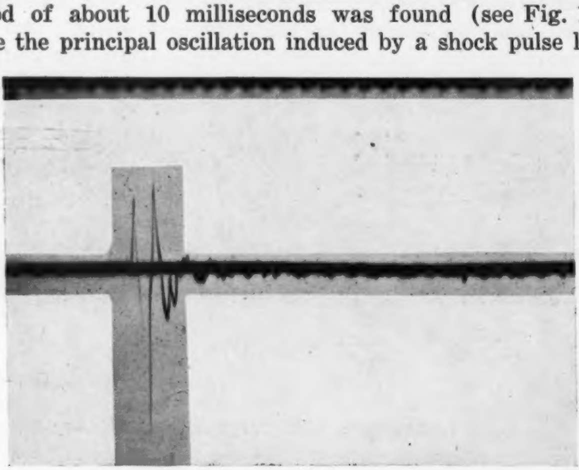

Fig. 16. Similar to above. Pulse 36" from ear.

about 1 millisecond, it enters the cochlea before the reflex muscle contraction can be initiated, hence this normal physiological mechanism for protecting the organ of Corti from loud

sounds is not effective in the case of sounds from shock pulses and similar brief pressure changes.

Distance of the subject from the shock pulse source is also important in determining the amount of trauma since the tremendous pressures developed at the source are rapidly dis-

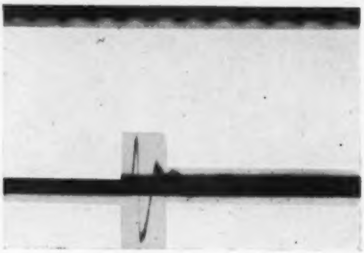

Fig. 17. Reduced movement of the malleus when shock pulse originates just behind the external meatus.

sipated. While one position may be extremely dangerous at a short distance, beyond this position much less trauma will occur. Near its source, the intensity of a shock pulse falls off more rapidly than the inverse square law for ordinary sound (see Figs. 15 and 16).

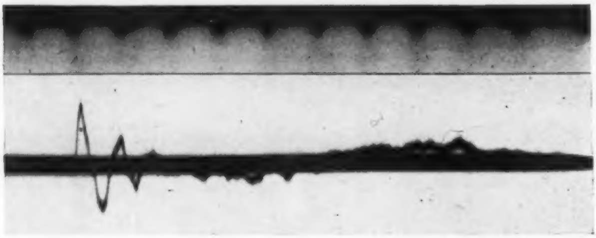

Fig. 18. Similar to above. Gun fired to one side of external meatus.

The position of the ears with respect to the incoming shock pulse is important in determining the final trauma (see Figs. 17 and 18). The head acts as a shield and to some degree protects the ear facing away from the oncoming wave. On the other hand, the ear facing the wave is exposed to a pressure doubling effect. Thus the ear facing the oncoming shock

will be more traumatized than the ear on the opposite side of the head.

Active assistance to the ear can be obtained in a number of ways. The pulse may be blocked from the external canal by

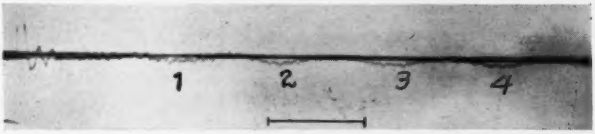

Fig. 19. Shock pulse transmission through thin metal plate shielding canal.
Note superimposed 100 cycle oscillation from thin metal plate. 1, 2, 3, 4. Bracketed line in all figures = 10 milliseconds.

covering the meatus with the palm of the hand or plugging it with a finger; however, a thin metal plate held between the ear and the pulse source interferes little with the transmission of the pulse to the conducting mechanism and in addition sets up its own oscillating disturbance (see Fig. 19). On the other hand, the pulse can perhaps be made to enter the middle ear through the nose and mouth at the same time it

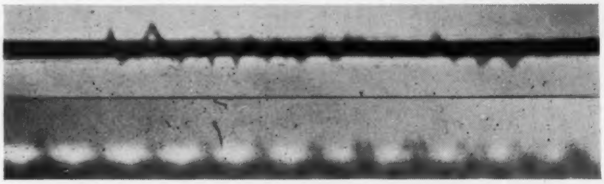

Fig. 20. Shock pulse response of the malleus when the external canal is plugged with beeswax. Succeeding waves about 2,500 cycles per second.

enters the canal by voluntary opening of the Eustachian tube. Now, the forces acting to move the drum from its resting position would tend to be neutralized. Furthermore, shielding the ear from the pulse can be effected by ear flaps, head phones, barriers, constructed or natural, etc. Of course, obturators for the canal are variously effective in stopping or reducing the pulse. Vaseline, wet cotton or beeswax in the canal of a fresh temporal bone greatly reduces the amplitude of the important initial oscillation of the malleus produced

by the shock pulse from a 32-calibre blank cartridge (see Figs. 20, 21, 22 and 23).

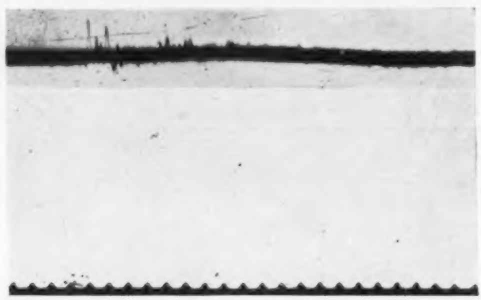

Fig. 21. Shock pulse response at the malleus when the external canal is blocked with glycerine-soaked cotton. (T) 1,000 cycle timing wave.

Note reduction in amplitude of initial oscillation—compare with Figs. 5 and 6. The high frequency of the succeeding oscillations (about 3,000 per second) is also noteworthy.

Fig. 22. Shock pulse response at malleus when conducting mechanism is protected by wet cotton in external canal.
Bracketed line = 10 milliseconds.

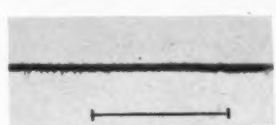

Fig. 23. Similar to above.

SUMMARY.

a. An experimental investigation of the effect of explosions on the human conducting mechanism was carried out on fresh temporal bones.

b. The stimulus used was the shock pulse from a 32-calibre blank cartridge fired from a starting pistol.

c. The reactions of the conducting mechanism to the shock pulse are analyzed and their clinical significance pointed out.

d. Protection to the ear is considered and illustrative records are presented.

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BERNOULLI'S THEOREM AND UPPER RESPIRATORY DRAINAGE.

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When my paper on this subject was presented last year before the New England Otolaryngological Society,* some skepticism was expressed as to whether one can get suction in the sinuses when he blows his nose.

In order to convince myself of the validity of the proposition, I consulted specialists — not in rhinology but in engineering. My first conference was with Mr. Ralph Booth and Mr. Everett Hume, of the engineering firm of Jackson and Moreland, of Boston, and later, through Mr. Booth, with Prof. Otto Koppen, of Massachusetts Institute of Technology, in Cambridge. Prof. Koppen is an outstanding authority in the field of aerodynamics and high speed pursuit plane design. *Without exception, these gentlemen expressed surprise that anyone would question the Bernoulli effect in the nose.*† As Mr. Booth expressed it, "A jet of air in the nose, delivered through passages of varying cross-section, would inevitably, in those areas of lower cross-section and hence higher velocity, cause suction to be established. When in the nose the entrances to the sinuses are at sufficiently constricted area points, suction must be caused in the sinuses."

Although Bernoulli[1] propounded his theory some 200 years ago and it is so commonly accepted that it is referred to in almost every elementary text of physics and is applied in hydraulic and aeronautical engineering, it is not ordinarily explained or applied in the physiology of respiration.

Under the heading of "Energy Transformations in Fluid Movement," MacLeod[2] describes the Bernoulli principle as it applies to the blood stream.

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*Nov. 15, 1944, at Massachusetts Eye and Ear Infirmary.

†Words in italics by writer.

Editor's Note: This ms. received in Laryngoscope Office and accepted for publication, July 11, 1945.

"Flow of fluid in a system of tubes is always from a place of greater free energy to one where the free energy is less; and the free energy lost is liberated as heat. The pressure in a fluid is exerted at right angles (normal) to the surface with which it is in contact and is everywhere the same at the same depth; at other depths it increases in proportion to the depth and the density of the liquid. The available energy of fluid in a system of distensible pipes carrying fluid to some given point may be present in three forms: *a.* as the potential energy of position, due to the height of the fluid above the given point; *b.* as pressure energy, or energy stored in the system as the result of work done against an elastic system by compressing the fluid and by stretching the wall of the tubing; *c.* as kinetic energy due to the velocity of the fluid. In flow through a system of tubes the sum of these three forms and any heat liberated in friction is constant throughout the system; this statement is Bernoulli's theorem."

In the language of the street, if a fluid is sufficiently forced through a gradually narrowing channel, it attains a velocity which allows neither the time nor the inclination for it to exert much pressure at right angles to the stream.

In his excellent and comprehensive text, "Applied Physiology of the Nose," Proetz[3] dismisses the subject with one short paragraph:

"Air exchange through the ostia is sometimes attributed to the Bernoulli principle, upon which the atomizer and the Venturi valve are constructed, but this is a fallacious conception, as the necessary constrictions do not normally exist in the nose in relationship to the sinus openings. The interchange of air must depend solely upon the pressure fluctuations set up by the thoracic excursions, in combination with the constriction at the naris."

Weeks of work by a librarian have failed to uncover any reference to Bernoulli on the subject of sinus drainage. I am indebted to Dr. Arthur W. Proetz for the only reference I have been able to find on Bernoulli and sinus drainage. In discussion of a paper read by Dr. Delbert K. Judd[4] before the Chicago Laryngological and Otological Society, Dr. Alfred

Lewy[5] said, "The mechanical contrivance known as an injector has been used by engineers to produce a flow from adjoining cavities through a pipe, simply by passing a jet of steam or air through a small pipe past an opening, corresponding to the ostium of the nasal sinus. That is what one does when one blows the nose."

Our available information on histological structure, secretion, ciliary action and even gaseous exchange between nose and sinuses during normal respiration has been beautifully presented in our current literature; but experiments show that there is a force which we apply when we blow our noses

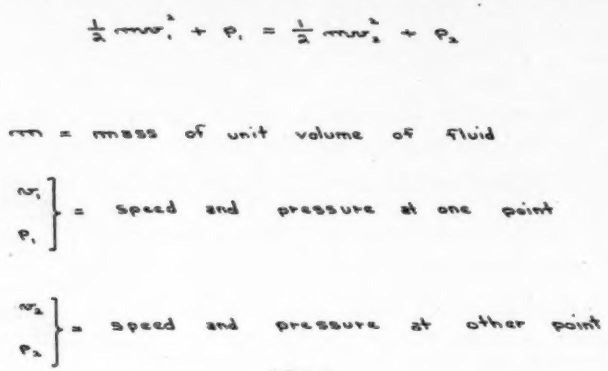

Fig. 1.

or sneeze which is momentarily more powerful in sinus drainage than the combined action of all the cilia of the largest maxillary antrum.

What is Bernoulli's theorem? To understand its full import, one must be a mathematician — which I am not (see Fig. 1) —

$$\frac{1}{2} M V_1^2 + P_1 = \frac{1}{2} M V_2^2 + P_2$$

Where M = Mass of unit volume of fluid

$V_1 + P_1$ = Speed and pressure at one point

$V_2 + P_2$ = Speed and pressure at another point

(No allowance for loss of pressure due to friction or turbulence.)

Bernoulli evidently viewed his theory from this altitude of higher mathematics. From my very elementary knowledge

of this science, I can see it only from below. One text of physics[6] expresses it in this manner: "In a fluid which is in motion, there is a decrease in pressure wherever the speed is increased, and an increase in pressure wherever the speed is

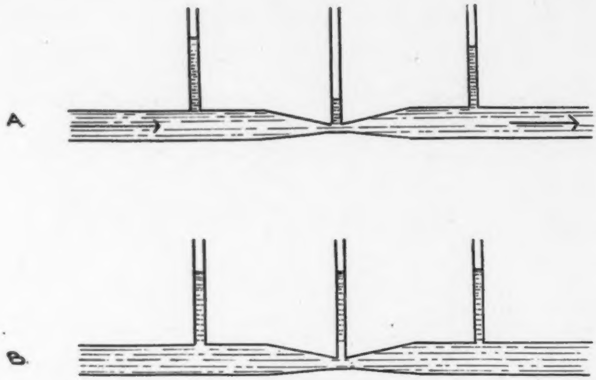

Fig. 2.

decreased." This is best shown in a pipe line of water which is constricted and then widened (see Fig. 2A). This is in contradistinction to a similar pipe line in which there is no flow of water. Of course, there would be no difference of

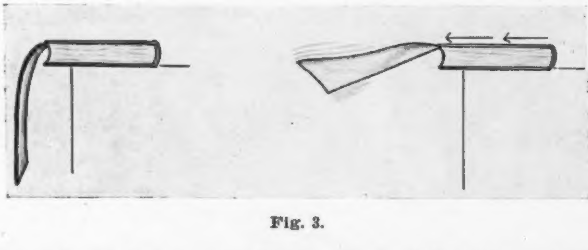

Fig. 3.

pressure in such a case — the pressure at the three positions would be identical (see Fig 2B).

Bernoulli had a viewpoint which was very much alive, and he made a clean-cut distinction between static and kinetic forces.

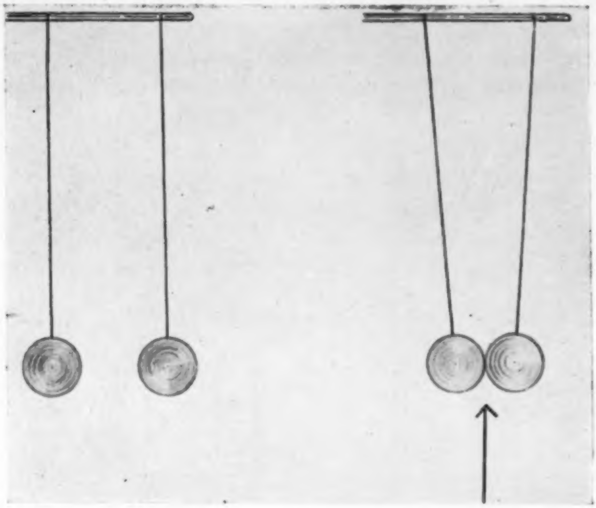

Fig. 4.

Common illustrations of Bernoulli's principles are:

1. Hold a strip of paper under your lower lip and blow your breath forcefully. The current of air which you blow from your mouth has an area of diminished pressure around it, and the strip of paper will rise to meet the lower side of the current (see Fig. 3).

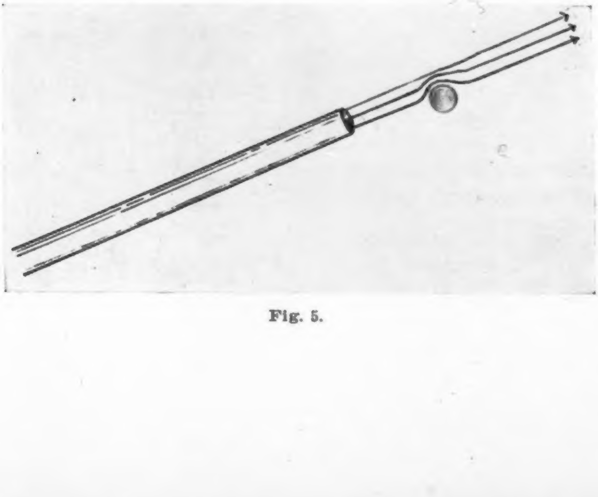

Fig. 5.

2. Suspend two light balls from the ceiling about $2\frac{1}{2}$ inches apart and blow your breath between them (see Fig. 4). One might think that this draft of air would blow them apart, but such is not the case. The diminished pressure on the sides of the current draws the balls together.

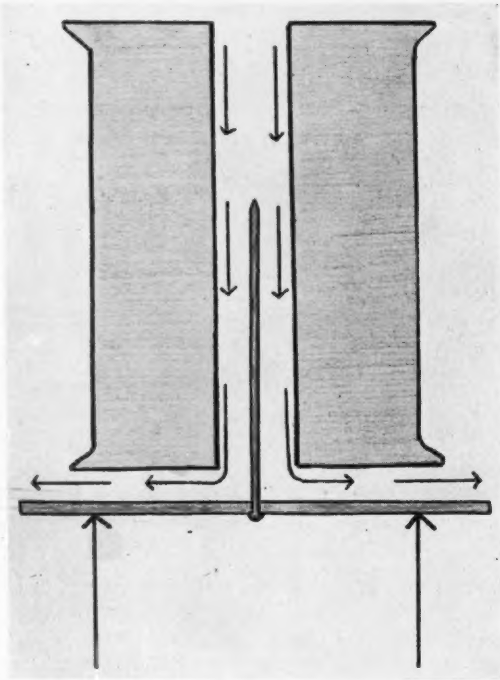

Fig. 6.

3. If one has a constant jet of air directed upward at an angle and places a ping-pong ball on the under surface of the current, the ball will be held there indefinitely as long as the proper velocity of the stream is maintained (see Fig. 5).

4. Take an ordinary thread spool and a small piece of cardboard with a pin stuck through its center (see Fig. 6). Place the pin through the hole in the spool. Try to blow the card

away from the spool. You cannot do it. Now, hold the card on the under side of the spool when the spool is directed downward. Blow into the spool and take your finger away. As long as you keep blowing, the card will hug close to the spool because the current of air which blows between the cardboard and the spool produces a partial vacuum, and the atmospheric pressure below the cardboard pushes it upward toward the spool. As soon as your breath is spent, the cardboard drops by gravity to the floor.*

5. Two steamships are running a near parallel course in the same direction, and they come close together. Suddenly,

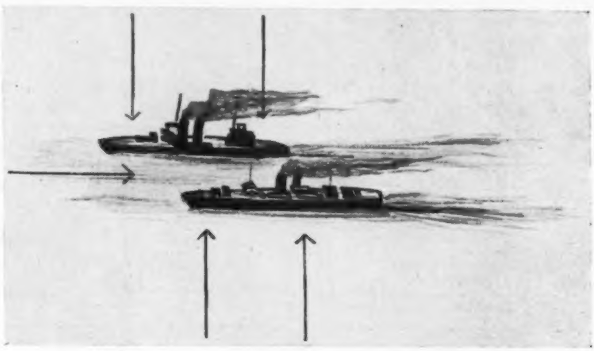

Fig. 7.

some unseen force grasps them, and they collide broadside — this happens in spite of all efforts to avoid a collision (see Fig. 7). What has happened is that they have run into Bernoulli's theorem. Although the water through which they steam is still, there is, in effect, a swift current flowing between them, and Bernoulli's law comes into action — the more rapid the current, the less the pressure of water to hold

*I told my friend and garageman, Eppo Walvius, of the spool and card trick. He expressed his skepticism and immediately produced from his work bench a large wire spool and stuck a cotter pin through a heavy piece of cardboard. Everything he had around the garage was so heavy that I began to have qualms as to how the experiment would work out. He then placed a pressure hose over the upper end of the spool and turned on a blast of air. The cardboard shot from the spool like a chinaberry from a popgun! When I had him reduce his pressure, the trick worked in orthodox fashion. Of course, 125 pounds of pressure does not allow much chance for the Bernoulli principle to act when we consider that atmospheric pressure is only 15 pounds.

them apart, and the more inevitable the force which causes them to come together. This explains not only accidents at sea but is also the explanation of numerous aeroplane collisions in close formation flying.

6. Those of you who are baseball fans will be interested to know that the Bernoulli principle explains the curved ball. The pitcher gives the ball a rapid lateral spin as it leaves his hand, and the ball, because of inequality of relative speed against the air on the two sides, travels not in a straight line but in an arc.

7. The common atomizer which we employ in our specialty utilizes this principle. A current of air is expelled from the bulb. This current comes in close apposition to another tube which extends into the liquid of the bottle. In response to the partial vacuum about the air stream, atmospheric pressure forces the liquid up the latter tube and into the current—thus making the spray.

A modification was suggested by Mr. Francis O'Brien, of the Department of Physics, Lawrence High School. He discussed the Bernoulli theorem with me before I wrote this paper, and he loaned me the text of physics which I quoted above. He was so interested in its application to physiology that he and his daughter experimented with it at home. Their only available apparatus was an old bicycle pump. They placed two books flat and close together on a table and bridged them with a sheet of paper and pumped a stream of air into the vestibule. On every thrust of air under the paper it would bend down appreciably. Mr. O'Brien made the correct observation that the paper would depress most on the first part of the piston thrust. I deduced from this that the Bernoulli force was most active when a current of air was suddenly started and tapered off when the velocity became constant. From this I concluded that a number of short "snorts" would be a more effective way of blowing one's nose than a prolonged blow; however, when I repeated Mr. O'Brien's experiment in my office with the Ritter pressure system, I found that the paper stayed in a fully depressed position as long as the stream of air was maintained. The reason the paper had returned to its original position on the

last part of the bicycle pump stroke was simply due to the fact that the pump could not keep up its initial output. Mr. O'Brien's experiment is a very simple and dramatic answer to any doubting Thomas.

One could add innumerable examples of this force, such as that which tends to pull your straw hat under a fast moving train as you watch it go by. But, let us try to apply Bernoulli's theorem to such a commonplace experience as the blowing of one's nose.

Its most effective aid in drainage is applied when the sinus discharge is near the ostium. This may be accomplished by excessive sinus secretion, swelling of sinus mucous membrane (causing displacement of secretion), ciliary action or postural drainage — or any combination of these factors. Once the mucus or mucopurulent discharge is in close vicinity to the patent ostium, a sudden short "snort" is very effective in draining the sinus. We have all experienced on recovering from a head cold the relief obtained by clearing our nasal vestibules of mucus and again breathing freely, but sensing a feeling of fullness in a maxillary antrum, we would blow our nose again and spoil a handkerchief with what must have been the entire antral content.

Also, the inelegant practice of "hawking" and spitting is an effective means of cleaning out the posterior ethmoids and sphenoidal sinuses. A sudden, forceful inspiratory effort, which in itself causes a slight negative pressure at the ostia which are proximal to the point of maximal constriction in the vestibule combined with the Bernoulli principle gives a double-action suction.

This principle does not apply exclusively to the nose, for a cough does not only clear the tracheobronchial tree of secretion which is already in the tubes, but it sucks free mucus plugs which may be obstructing other bronchi and is an ideal mechanism for scavenging the pyriform sinuses of the larynx.

Although it is not in the province of this paper to discuss it here, we should consider the Bernoulli principle wherever there is a current in the body of any appreciable velocity.

The fast moving currents of blood in the large vessels may explain the sudden dislodgement of a clot in the mouth of one vessel and its shift to another site. Also, a fast moving stream of urine in the urethra may have a definite scavenging action on the numerous glands and ducts which empty into it.

OBSERVATIONS ON BERNOULLI ACTION IN SINUS DRAINAGE.

There must be a rapid jet of air released in the vicinity of a sinus ostium which does not impinge on the ostium; also, there must be no obstruction distal to the ostium which will neutralize the Bernoulli effect. In the case of the maxillary antrum, there must be some constriction in the breathing space at or near the ostium in the middle meatus. This jet of air does not have to pass immediately over the ostium of the antrum. In fact, in a number of my experiments it worked very satisfactorily when the jet played along close to the nasal septum.

My engineering consultants brought out the fact that the constant stream of air in my experiments would not give a true picture of the quickly accelerating force which one applies on a convulsive compression of his lungs as in a sneeze. They were inclined to think that under such conditions my figures for steady flow might be exceeded materially.

One might take the position that the experiments which I have conducted in the human nose are quite artificial, and that favorable conditions for the Bernoulli principle to act are not ordinarily found in the living. I freely admit that the wide breathing space found in an atrophic nose would never give an opportunity for a Bernoulli effect unless the nose were filled with crusts which blocked it sufficiently, but on the other hand, we do not need to blow our noses when the sinuses are empty, and when the sinuses need emptying there is usually present enough nasal congestion to give the necessary constriction to the air passage to permit formation of rapidly flowing jets of air. While my experiments were done on the maxillary antrum, and it is shown by the experiments that the constriction is necessary near the ostium, this does not mean that the whole nose should be blocked posterior to the antrum. It means that there must be constriction in the vicinity of the

antral ostium in order to give the jet effect for emptying that particular sinus.

The question can also be raised as to what effect diminished pressure will have in emptying the maxillary antrum which is only partially filled with pus. Of course, in this case if the antrum were filled with water, there would be no other effect than the diminished pressure of the air above the level of the water. In the case of mucus, however, the cilia would bring this toward the ostium. Thus, when the Bernoulli effect is active, the mucus is pulled and fed into the main slip stream of air, and it will probably continue to work on it until the strand of mucus is broken. By this time the expulsive effort of the lung is probably about over. Atmospheric pressure re-establishes itself through the patent ostium into the sinus and the procedure can be repeated with the next blow.

I reported to my chief, Dr. Mosher, the results of my first experiments when I thought that one must have constriction of air space proximal to the sinus ostium, and he seemed to be pleased that I was able to attain suction, even though the conditions under which I obtained it were somewhat artificial. He was much more impressed, however, when he found that the best results were obtained when the maximum constriction was in the immediate vicinity of the ostium involved. Thus, when the right maxillary sinus is diseased, the natural vascular reaction of congestion of the turbinates is in the region of the right maxillary ostium, and that is the condition which will produce the best Bernoulli effect. This holds true of all the other sinuses. After all, one should not attempt to improve on nature.

I described to Prof. Koppen the atrophic condition of the turbinates in the dead skull and how I had built them up with plasticine to get the proper constriction for suction effect. He was of the opinion that the natural engorgement of the turbinates which causes a smooth, gradual apposition of soft mucous membrane affords a far more streamlined and efficient Venturi passage than I could construct offhand of firm material. Even though the air passage might have some

irregularities, they would tend to smooth out when a forceful jet of air passes through.

If we are to understand the Bernoulli effect in the nose, it is necessary for us to have some sort of a conception of how a Venturi tube works.

What is a Venturi tube? It is a round tube whose inner diameter gradually diminishes in a streamlined curve toward the "throat," or the point of maximum constriction, and then the diameter gradually and quite symmetically increases on the discharge end. It is designed to give the highest velocity to the air flow at the throat and must have the minimum loss of energy due to skin friction or turbulence. For all practical purposes, the tube is reversible. To use a very simple illustration, a Venturi tube could be described as one having the rough form of two megaphones placed mouth to mouth. While such a simple Venturi tube would work, it is not nearly so efficient as would be a tube whose inner surface approaches and leaves the constriction in free sweeping curves which are designed to cause the least possible turbulence to the air stream — in other words, the inner surface is streamlined for maximum efficiency.

Now, let us consider some simple facts about wind tunnels, which are nothing more than overgrown Venturi tubes. I understand that some of these have been constructed which are large enough to accommodate a full sized aeroplane in their throats.

A large air propeller is placed at the discharge end of the tunnel and air is sucked through. The speed of the air current through the throat is determined by a water manometer which is connected to a right angle tap at the point of maximum constriction — the greater the speed the higher the suction reading on the manometer.

When Prof. Koppen showed me one of his wind tunnels at Massachusetts Institute of Technology, there were a number of points which puzzled me, and I asked him many questions. Just as there are questions that our small children ask us which cannot be answered simply, there were many simple questions I asked Mr. Koppen involving factors which even

he could not teach me in an afternoon. In an effort to help me in my problem, he did not hesitate in answering "yes" or "no"—although he usually prefaced his remarks with "for all practical purposes." It was in this spirit that his answers were given and, if there are any inaccuracies of fact, you should hold me and not Prof. Koppen to account. Also, the answers are not given in his exact words, but in his meaning, to the best of my understanding.

Question: Why do you suck the air through the tunnel?

Answer: We draw the air through the tunnel because we obtain a smoother air flow than we would if the propeller were placed at the entrance.

Question: If you had two tunnels of equal size and design and you blew the air through one and sucked it out of the other at the same speed, what would be the difference in suction as registered on the manometers connected to the taps at the throats of the two tunnels?

Answer: If the velocity of the air stream at the throats is the same, the reading of the manometers would be identical.

Question: (The ostia of the numerous maxillary antra I have examined vary in size, shape and angle, and this fact inspired the following question.) I notice that the tap for the manometer on the floor of the tunnel throat was made at right angles to the air stream. Would it make any difference in the manometer reading if the tap were made at obtuse angles to the axis of the tunnel and pointing toward and from the direction of the air flow (see Fig. 8)? Also, if a large funnel were placed in a hole in the tunnel floor and it tapered to the tube connected to the manometer, would there be a difference in the manometer reading?

Answer: In all of these instances where the opening is connected to a closed manometer circuit, the readings would be the same providing no lip of the connections extended through the floor and into the air flow.

To continue my paper, let us make a Venturi tube of soft malleable silver. Let us assume, for sake of argument, that

it is smooth and well designed and highly efficient. We handle it carefully, for we know that should we drop it and distort it, some of its efficiency will be lost. We allow others to look at its highly polished inner surface, but they must not point at it with pencils, for the slightest roughening of this surface will increase skin friction and turbulence and lessen the velocity of the air stream at the throat.

Now, let us become destructive and scratch the inner surface with a file. Our Venturi tube is less efficient, but it still works. We strike it with a hammer and dent its beautifully

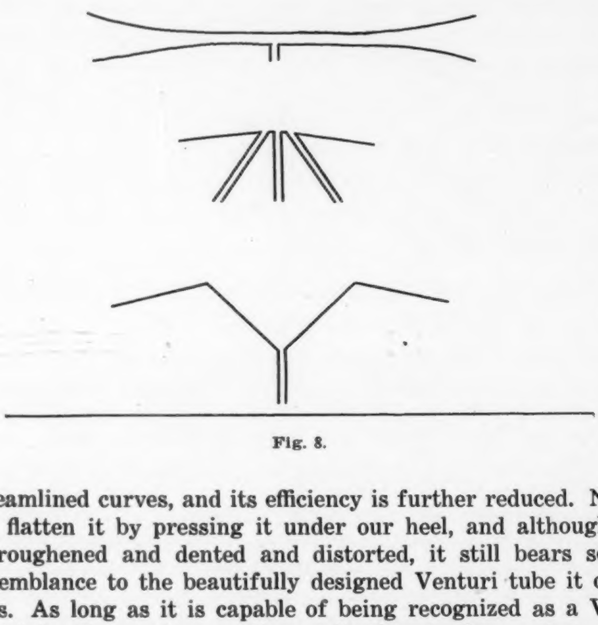

Fig. 8.

streamlined curves, and its efficiency is further reduced. Now we flatten it by pressing it under our heel, and although it is roughened and dented and distorted, it still bears some resemblance to the beautifully designed Venturi tube it once was. As long as it is capable of being recognized as a Venturi tube, it can show suction at its throat when a stream of air is passed through it, provided we have not caused too much obstruction to free air escape on the exhaust side.

So, in the nose we probably never find a perfect Venturi tube, but where the conformation of the air space merely

approaches it, we have suction applied to all ostia which are near the point of maximum constriction.

You might be skeptical as to the amount of suction which can be obtained from a jet of air blown from the lungs. Let us assume that we have under the most unusual conditions a perfect Venturi tube in the nose which is designed for the greatest possible velocity at its throat. Also, let us ignore skin friction and turbulence. Such a tube will exert roughly 53 per cent of its entering pressure at its throat.

Now let us blow through this tube at one-half pound pressure above the atmospheric of 14.7 pounds—thus the air enters the tube at 15.2 pounds absolute pressure. The pressure as shown by a manometer tap at the throat is 15.2 $\times$ 53 per cent, or 8.1 pounds. Now subtract this from 14.7 pounds and we have 6.6 pounds of suction. Imagine that! We blow our nose at a half-pound of pressure, and we exert more than 6½ pounds of suction at a sinus ostium!

Of course, such a condition would rarely, if ever, occur in the nose, but it does show something of the potential power of Bernoulli action.

PHYSIOLOGIC PROOF OF BERNOULLI ACTION IN THE SINUSES ON GROSS HUMAN SPECIMENS.*

The following experiments were done to prove the point on actual anatomical material. Our first attempts were entirely negative, and it became evident at an early stage in these experiments that if the Bernoulli effect were active, there would have to be certain favorable conditions which are not always present.

The first experiment was done on a fairly fresh cadaver (see Fig. 9A) in which the hypopharynx was plugged with vaselined gauze so that air would not escape into the trachea and esophagus. A trocar was inserted into the right antrum and connected to a U-tube water manometer. A wire retractor held the soft palate forward so that it could not act as a flap valve. A rubber tube of the calibre of a garden hose was

*This work was done in the Department of Anatomy, Tufts College Medical School, Boston, with the generous cooperation of Dr. Benjamin Spector, Professor of Anatomy.

placed in the mouth and the lips sealed around it. The source of air pressure was an ordinary air compressor with pressure tank such as is used in garages and filling stations, and the

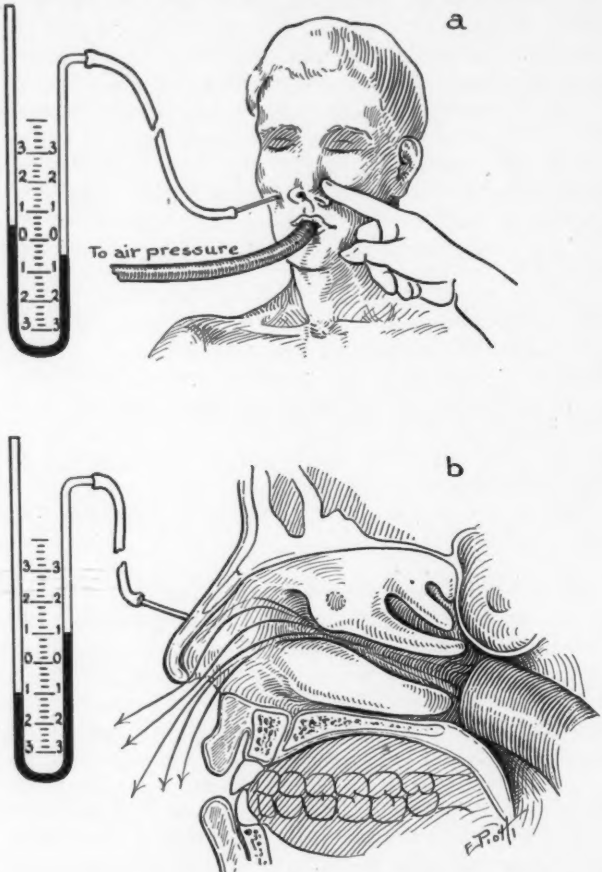

Fig. 9.

high pressure line was connected to a reduction valve, equipped with an air pressure gauge, which allowed adjustment to the pressure desired. While the usual text refers to

approximately two pounds as the maximum pressure which we can blow through our mouths, by actual test I found that I could momentarily hold a mercury manometer to approximately three pounds. This pressure of three pounds was the working pressure of the experiments. Three pounds of air were blown into the mouth, passed into the pharynx and out through the nose. The left nostril was held closed by finger pressure. A slight pressure in the right antrum was registered by the water manometer. The trocar was then inserted into the left maxillary sinus, and the experiment was repeated through the left nostril with similar results. This was repeated with varying pressures from one pound to 15, but at no time was there any suction demonstrated in the antra.

The experiments next were done on a decapitated head in which a rubber tube was fed back through the nose into the pharynx and esophagus. The pressure line was connected to this tube and air blown through it, escaping through the nose. Various positions of the tube were tried, allowing the air to escape into the region of the posterior choana, and various intermediate positions between there and the nostril. This was done on both sides, and at no time was there any demonstrable suction in the antra.

The next experiments were tried on a head which had been subjected to frontal section allowing direct access through the nasal pharynx to the posterior choanae. Inserting the pressure tube at three pounds' pressure, I tried various positions of the tube without success. I then took some plasticine — the material children use in making clay models — and inserted the tube in the upper part of the breathing space and packed plasticine around it. This time when the pressure of three pounds was turned on, there was definite evidence of suction as shown by the water manometer. I was still at a loss to know just what had gone on in the nose and attempted to locate the exact position of my tube and the plasticine by examination of the nose from the front through the nostril with a Holmes pharyngoscope. While I could see my tube extending about half-way into the nose, and could see plasticine all about, I could not locate the ostium of the antrum,

and my examination with the nasal pharyngoscope did not help me much.

The next step was a sagittal section (see Fig. 9B) of this specimen. The nasal septum, which was quite straight, was removed and replaced by plate glass. The experiments were conducted on each half separately. The flat turbinates of the skull were built up with plasticine to allow a jet to play along the middle meatus and over the region of the maxillary ostium. Ten millimeters of water suction showed on the manometer. This was repeated on four separate antra with similar results.

When I reported these successful experiments to my engineering consultants they were skeptical of my measurements and showed me that under more ideal conditions I should get much more suction for the amount of pressure I was employing. Later, I got 20 mm. of suction in an antrum by attempting a more streamlined approach to the area of constriction.

Conclusions: We can readily see, from the experiments on dead heads, that the Bernoulli effect has little or no influence in cases of atrophic rhinitis or in the over-ventilated breathing space we sometimes find postoperatively. This may be a partial explanation of the poor results of radical intranasal surgery.

While we want and must have some breathing space and drainage space in the nose, an over-wide vestibule tends to defeat the latter purpose entirely. This would indicate that one should be conservative not only in his intranasal surgery but also in his cauterization of turbinates.

Furthermore, even the use of shrinking drops should be guarded, as an over-ventilated nasal space precludes Venturi action.

Finally, if it should be commonly accepted that the Bernoulli principle is effective in sinus drainage, it will take some of the load from the shoulders of the overworked little cilia.

ACKNOWLEDGMENTS.

I wish to express my grateful thanks to:

Mr. Ralph D. Booth, Engineer, Jackson and Moreland, Boston, Mass.; Mr. Everett Hume, Mathematician, Jackson and Moreland, Boston, Mass.; Mr. Otto Carl Koppen, Professor of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.; Mr. Francis O'Brien, Department of Physics, Lawrence High School, Lawrence, Mass.; Miss E. Piotti, Medical Artist, Harvard Medical School, Boston, Mass.; Dr. John Fallon, Fallon Clinic, Worcester, Mass.; Dr. Benjamin Spector, Professor of Anatomy, Tufts College Medical School, Boston, Mass.; Dr. Harris P. Mosher, Professor Emeritus Otolaryngology, Harvard Medical School, Boston, Mass.—for frequent aid and criticism as the paper developed.

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BOOK REVIEWS.

Minor Surgery. Edited by Humphry Rolleston and Alan Moncrieff. Contains 174 pages and 30 illustrations. New York: Philosophical Library. 1944. Price $5.00.

This short book by various authors is designed for first-year students in surgery. It contains a little information about many subjects, and one wonders if the presentation of such a little knowledge may not be a dangerous thing. It would seem that the information imparted here could, in most instances, be more adequately given to the student by his instructor in the surgical and allied specialties clinics. T. E. W.

The Common Cold and How to Fight It. By Noah D. Fabricant, M.D. One hundred seven pages with Index and nine illustrations. Chicago: Ziff-Davis Publishing Co. Price $1.50.

This short book is presented for the layman and gives a fairly complete report of what is known about upper respiratory infections, their treatment and prevention It is written in concise and clear language and is illustrated adequately to emphasize the author's points. It should be helpful to the layman and perhaps also to those whose duty it is to maintain the respiratory health of school children. T. E. W.

Hay Fever Plants. Their Appearance, Distribution, Time of Flowering and Their Rôle in Hay Fever, with Special Reference to North America. By Roger P. Wodehouse, Ph.D., Associate Director of Research in Allergy, Lederle Laboratories, Pear River, N. Y. Published by Chronica Botanica Co., Waltham, Mass.: New York, G. E. Stechert and Co. 1945. Two hundred forty-five pages. Price $4.75.

The successful management of hay fever is dependent not only upon the clinical investigation of the patient's problem but also upon a knowledge of the plants which cause hay fever in a given locality. It is necessary, therefore, to determine the number and kinds of pollen grains in the atmosphere during the hay fever seasons and to correlate these findings with botanical field surveys.

There has been a great need for a text in which all this data could be compiled and consulted as a guide to obtaining this valuable information.

In this text Wodehouse describes all the plants known to cause hay fever, most of them reasonably suspected of doing so, and many which have been mentioned in hay fever literature, possibly wrongly.

In a previous publication Wodehouse presented a splendid text devoted to the study of pollen grains. In the present text he correlates the pollen grain descriptions with that of the botanical.

The text is well illustrated with many photographs and splendid hand drawings which were made by the author.

To those who are interested in the diagnosis and treatment of hay fever, this text is absolutely indispensable. Many hay fever patients should be forever grateful to the author for his splendid contribution, for in many instances satisfactory relief of his symptoms may be attributed to a great degree to the knowledge which the physician has acquired from the perusal of this text. F. K. H.

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